
MACROPALEONTOLOGY OF THE EOCENE CRESCENT FORMATION IN THE LITTLE RIVER AREA, SOUTHERN OLYMPIC PENINSULA, WASHINGTON

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ABSTRACT. In the upper part of the Crescent Formation in the Little River area, southern Olympic Mountains, Grays Harbor County, Washington, basalt units are intercalated with marine sedimentary units as much as 100 m thick. Ten macrofossil localities were found and 42 macrofossil taxa were identified to genus and/or species. These include 1 hexactinellid sponge, 1 colonial coral, 4 solitary corals, 1 inarticulate brachiopod, 2 articulate brachiopods, 1 polychaete worm, 1 scaphopod, 15 gastropods, 13 bivalves, 1 "gooseneck" barnacle, and 2 sharks. One new species is described and named: an inarticulate brachiopod, *Craniscus edwilsoni*, new species.

The macrofauna is dominated by bivalves, limpets, and brachiopods that lived on a hard substrate produced by the accumulation of volcanic-island or pillow basalt in shallow marine waters. After a short distance of postmortem transport into adjacent subtidal waters, the macrofauna and eroded basalt debris accumulated as pebbly deposits. Parts of the animals that were cemented to the basalt did not survive the erosion/transport processes. Locally, the pebbly deposits grade into overlying muddy deposits where soft-bottom-dwelling solitary corals, mobile gastropods, shallow-burrowing bivalves, and hexactinellid sponges lived.

Macrofossils in the upper part of the Crescent Formation in the Little River area indicate a middle early Eocene age equivalent to the molluscan "Capay Stage." Three of the genera previously known from only the Atlantic Ocean are reported for the first time from the Paleogene of the Pacific coast of North America. They are the brachiopod *Craniscus*, the "gooseneck" barnacle *Aporolepas*, and the shark *Palaeohypotodus*.

Eight genera, three tentatively identified genera, and 16 species (mostly mollusks) previously known from the Pacific coast are reported for the first time from the upper Crescent Formation. Of these, the gastropods *Diodora* and *Erginus* and the bivalve *Spondylus carlosensis* have their earliest record in the Little River area. A few of these previously known taxa may have immigrated into the Little River area from Alaska or Russia.

INTRODUCTION

The basement rock in the Olympic Peninsula of western Washington is the upper Paleocene to lower middle Eocene Crescent Formation (Snively, 1987). The formation consists predominantly of oceanic tholeiite basalt flows. Several models proposed for the origin of the formation were reviewed by Snively (1987). Most envisage accretion of seamounts. The upper third of the Crescent Formation ranges from a deep-to-shallow marine environment to one that is locally terrestrial with marine sedimentary rocks interbedded with the basalt flows (Cady, 1975). Locally, these marine sedimentary rocks contain fossils. There have been several detailed studies of the benthic foraminiferal assem-

blages (Rau, 1964, 1966, 1967), but, until recently, there were no detailed studies of the macrofossil assemblages. Prior to 1992, the previous macrofossil studies dealt with a few new species of mollusks or corals mainly from the type section of the Crescent Formation at Crescent Bay (Fig. 1) along the south shore of the Strait of Juan de Fuca. Squires et al. (1992) studied the shallow marine upper part of the Crescent Formation at Pulali Point (Fig. 1), west of Seattle, and made the first detailed analysis of a macrofossil assemblage in the formation. Although Weaver (1943) did a monograph on Tertiary marine macrofossils from Washington and Oregon, his coverage of species from the Crescent Formation was very limited.

The present study is a continuation of work by the authors on the paleontology of little-studied early Eocene macrofaunal assemblages in the Olympic Peninsula. It summarizes the macrofossil assemblages of the upper Crescent Formation in the Little River area, southern part of the Olympic Mountains, Grays Harbor County, Washington (Fig. 1), and discusses the paleoenvironmental, biostratigraphic, and paleobiogeographic aspects of the assemblage.

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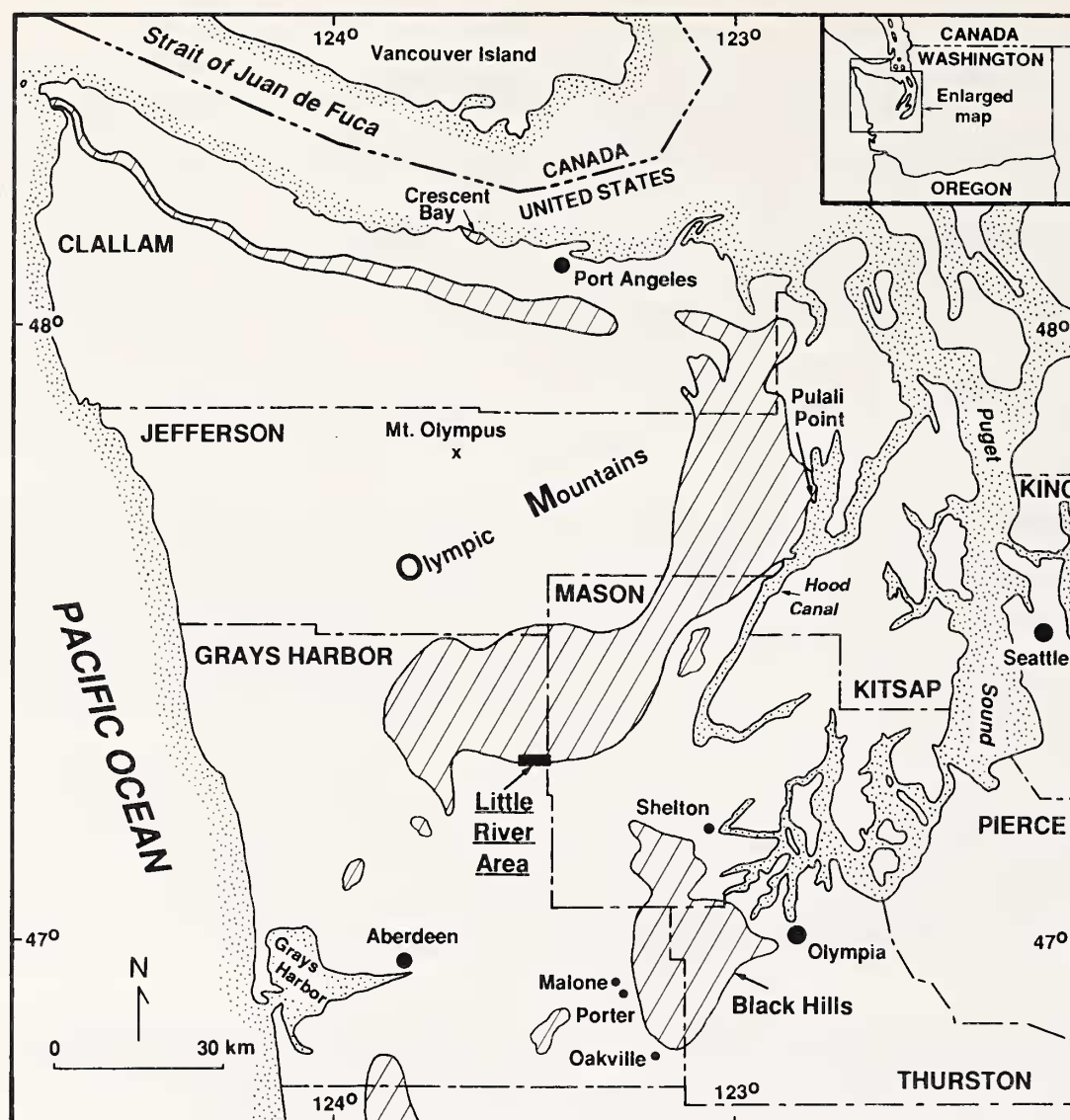


Figure 1. Index map showing the location of the Little River area and outcrops (shown as parallel inclined lines) of the Crescent Formation (compiled from Tabor and Cady, 1978; Walsh et al., 1987) in the Olympic Peninsula, Washington.

The most detailed geologic mapping of the study area and vicinity was done by Rau (1966), whose work was used by Tabor and Cady (1978) in their compiled geologic map of the Olympic Peninsula. Rau (1966) did a detailed study of the benthic foraminiferal assemblage from the upper Crescent Formation in the study area and noted the presence of mollusk shell fragments in some of the beds. Armentrout (1973) identified the genera of a few of the more abundant mollusks. Our study is the first species-level study of the macrofauna in the Little River area.

Grain and clast (> 2 mm) size terms used in the present study are from Wentworth (1922). Lithologic and grain roundness terms follow those used in Compton (1985). The molluscan stage terminology used in this report stems from Clark and Vokes (1936), who proposed five mollusk-based provincial Eocene stages: "Meganos," "Capay," "Domengine," "Transition," and "Tejon." The stage names are in quotes because they are informal terms. Givens (1974) modified the use of the "Capay Stage," and it is in this modified sense that "Capay Stage" is used herein. Saul (1983) correlated the stages to the calcareous nannofossil zonation of Okada and Bukry (1980).

STRATIGRAPHY

Outcrops of the upper Crescent Formation in the Little River area are part of a monoclinical structure in the foothills along the southern side of the Olympic Mountains. The outcrops strike generally northwest and dip about 40° southwest. Although partial sections were measured at all the places where macrofossils were collected, structural and facies complexities, as well as dense forest cover, make it extremely difficult to correlate these sections. As a result, the stratigraphy of the upper Crescent Formation in the study area can be depicted only in an idealized manner (Fig. 2), with the stratigraphic positions of the macrofossil localities only shown approximately. California State University, Northridge (CSUN) localities 1553, 1553a, and 1554 are especially tenuous due to fault problems.

Only the upper part of the Crescent Formation was studied. Most of the non-sedimentary rocks are weathered pillow basalt. Some individual flows, especially in the lower part of the section, are intensely fractured and commonly appear to be brecciated or sheared. Rau (1966) observed these fracture zones and attributed them to autobrecciation, in some cases, and to structural deformation, in others.

The main macrofossiliferous sedimentary unit is approximately 100 m thick and consists mostly of dark green, very fine to medium basaltic sandstone with rounded to subrounded grains. Near the base of this sedimentary unit, there are pebble conglomerates (clasts up to 13 mm in length) that grade rapidly upward into coarse sandstone. These pebble conglomerates and associated sandstones locally contain many macrofossils. At CSUN locality 1553 (Fig. 3) there is a 1-m-thick sequence of these rocks that is the most fossiliferous deposit in the study area. Macrofossils make up as much as 30 percent of the clasts and form a coquina. Thirty-five species were found associated with a diverse microfossil assemblage. Intermixed with the macrofossils are subrounded basalt clasts that range in size from granule to medium (up to 11 mm in length). There are also some large pebble-sized (up to 20 mm in length) lumpy calcareous nodules. The matrix of the pebble conglomerate is mudstone and the amount is variable. In the upper part of the 1-m-thick sequence, the matrix makes up 60 percent of the rock, and the rock type is a sandy mudstone with shell debris and some scattered small pebbles of basalt.

Locality 1553 is similar to localities 1554, 1555, and 1557 in rock type and abundance and diversity of macrofauna. At locality 1557, there is a thin lens of *Glycymeris* sp. cf. *G. crescentensis* coquina. The stratigraphic position of CSUN locality 1555, which is known with more certainty than for CSUN localities 1553, 1554, and 1557, is in the lower part of the main sedimentary unit. Localities 1553, 1554, and 1557, therefore, also are placed in the lower part of the section (Fig. 2). Approximately 2 m upsection at locality 1553, there is a 3-m-thick, pyritic argillaceous black mudstone with sparse macrofossils, including some hexactinellid sponges. Locality 1553a is in this black mudstone, which is not present elsewhere in the study area.

Near the middle of the main sedimentary unit, macrofossils were found at only one locality (CSUN loc. 1560). A few species were recovered from silty very fine sandstone to argillaceous fine sandstone. At the top of the main sedimentary unit, there are pebble sandstones that do not have muddy matrix and have only a few macrofossils.

The basalt unit overlying the main sedimentary unit is approximately 90 m thick. It consists mostly of numerous, thick-bedded pillow basalts, but near the top of the unit, in the vicinity of locality 1556, there is a flow that shows columnar jointing along its lower and upper contacts. The middle of the flow is massive but fractured. There are minor deposits of siltstone interbedded with the basalt unit, but these siltstones contain no macrofossils.

Unconformably overlying the Crescent Formation in the Little River area is a sequence of gray micaceous thin-bedded mudstone, siltstone, and silty sandstone. Rau (1984) indicated on a geologic sketch map that these strata should be mapped as part of the Humptulips formation that he informally named

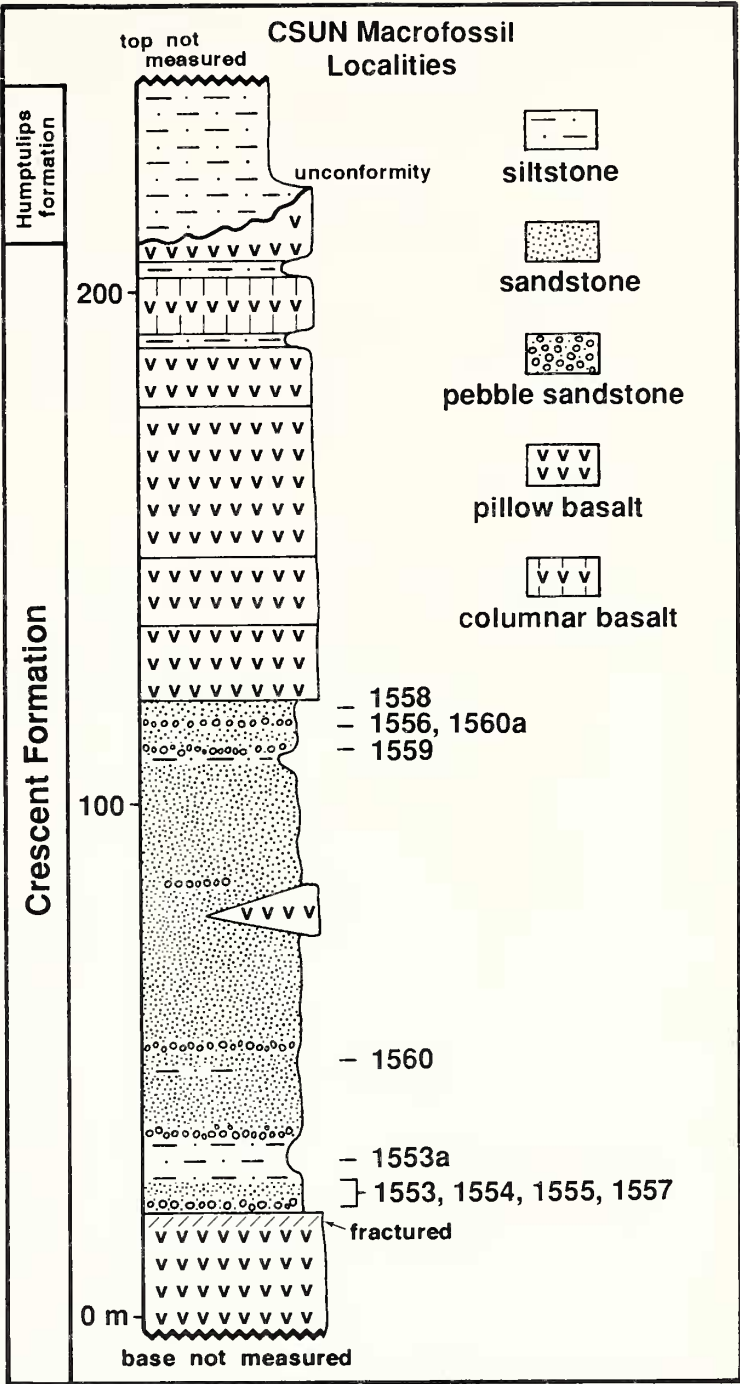


Figure 2. Idealized stratigraphy of the upper Crescent Formation in the Little River area and approximate stratigraphic positions of CSUN macrofossil localities.

and recognized just west of the study area. These strata were originally mapped as “sedimentary rocks of late Eocene age” (Rau, 1966; Tabor and Cady, 1978).

Rau (1966) mapped a nearly continuous band of upper Crescent Formation sedimentary rocks above the highest volcanic rocks throughout the study area. This interpretation does not correspond to the general structure of the Crescent Formation within the study area as we interpret it, and this band of sedimentary rocks could not be found at all of the areas indicated by Rau (1966). In addition, basalt is exposed in roadcuts in the south half of SW¼ of the SE¼ of section 12, in an area previously mapped (Rau, 1966) as “sedimentary rocks of the late Eocene age” (= Humptulips formation). Basalt and sedimentary rocks of the Crescent Formation are also present in the NE¼ of the NW¼ of section 15, again in an area mapped (Rau, 1966) as Humptulips formation. Detailed work (beyond the scope

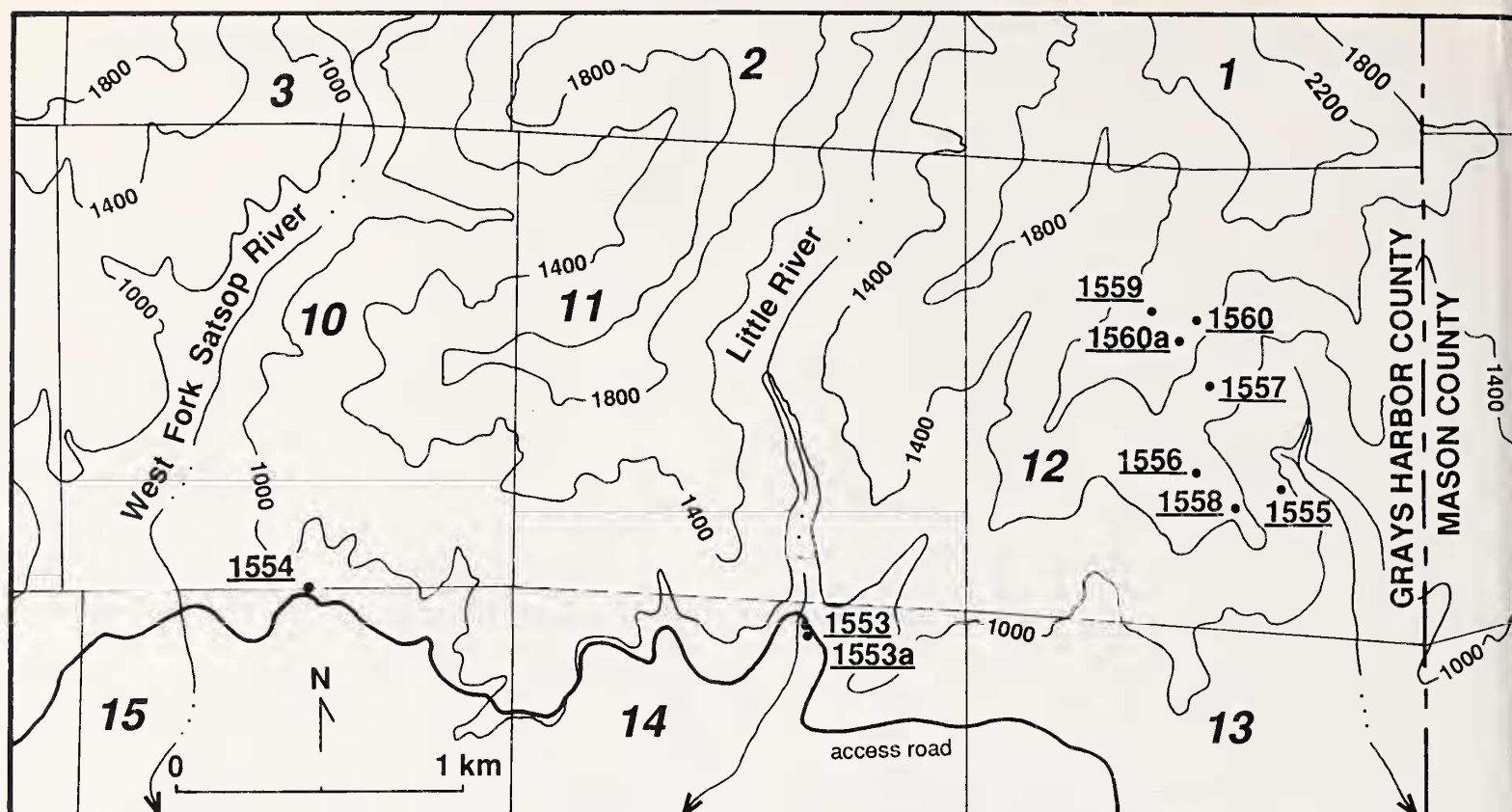


Figure 3. Index map showing location of CSUN macrofossil localities in the Little River area. Contour interval is 400 ft. Base map is U.S. Geological Survey, 7.5 minute, Grisdale, Washington, quadrangle (provisional edition, 1990).

of this paper) on the structure of this part of the Crescent Formation is needed to accurately determine the stratigraphic relationships of the macrofossiliferous strata and the basalt units.

Rau (1966) also believed that the sedimentary deposits in the vicinity of locality 1553 are above the stratigraphically highest volcanic rock because there is no overlying basalt there. Our interpretation is that stratigraphically higher volcanic units have been eroded or faulted out in the vicinity of locality 1553 (as well as loc. 1554). At locality 1553, the contact with underlying pillow basalt is a vertical fault of unknown displacement.

FAUNAS

A total of 776 macrofossils were collected from 10 localities (Fig. 3). Preservation ranges from poor to good, but many of the fossils are in poor condition. In addition, fossils in mudtone matrix are easily destroyed if not carefully removed from the brittle matrix. Limpet gastropods are mostly preserved as internal molds. Most of the macrofossils are about 10–15 mm in maximum dimension.

Forty-two of the macrofossil taxa could be identified to genus and/or species. These include 1 hexactinelled sponge, 1 colonial coral, 4 solitary corals, 1 inarticulate brachiopod, 2 articulate brachiopods, 1 polychaete worm, 1 scaphopod, 15 gastropods, 13 bivalves, 1 “gooseneck” barnacle, and 2 sharks. Other taxa too poorly preserved for generic identification include calcareous sponges?, bryozoans, minute serpulid worms, a few gastropods and bivalves, an anomurid (thalassinoid) shrimp claw, a

xanthid? crab claw, sea urchin spines and plates, and two fragments of irregular echinoids.

On the basis of comparison with Crescent Formation macrofaunal data in Squires et al. (1992), eight genera, three tentatively identified genera, and 16 species (Table 1) are reported for the first time from the Crescent Formation. Two of the species, *Calyptrea diegoana* and *Brachidontes (B.) cowlitzensis*, have been reported previously from the Crescent Formation, but the previous records were questionable (Squires et al, 1992). One new species is reported from the Crescent Formation in the Little River area. It is the inarticulate brachiopod *Craniscus edwilsoni*, new species.

Rau (1966) made a detailed study of benthic foraminifers from the upper part of the Crescent Formation in the study area and found 55 species. His localities F-36 and F-37 are in the immediate vicinity of locality 1553. At locality 1553, abundant large benthic foraminifers, as well as some fish otoliths, are detectable with a hand lens. A few radiolarians were found at localities 1553 and 1560.

A microfossil sample was collected at locality 1553 and analyzed for benthic foraminifers and calcareous nannofossils. The benthic foraminiferal assemblage is dominated by a robust species of *Amphistegina*. There are also fragments of probable discocyclinids, along with rare specimens of *Quinqueloculina* sp. and *Nodosaria latejugata* Gümbel, 1868 (Heitman, pers. comm., 1992). Only very rare, poorly preserved specimens of the calcareous nannofossils *Dictyococcites* sp., *Coccolithus pelagicus* (Wallich, 1877), and *Toweius* (?) sp. were found (M.V. Filewicz, pers. comm., 1992).

DEPOSITIONAL ENVIRONMENT

The grains and clasts in the upper Crescent Formation sedimentary deposits were derived by high-energy erosion of pillow basalts that were extruded into shallow water. These basalt buildups provided a hard-substrate habitat for marine invertebrates, and macrofossils in the sedimentary deposits are indicative of shallow water and were predominantly hard-substrate-dwelling species. All of these animals were transported after death into adjacent subtidal waters where there were soft-substrate sands and muds. The distance of postmortem transport was not far because the shells are unabraded and mostly complete.

Four types of hard-substrate-dwelling animals are present that would have been able to live on surfaces of the pillow basalts. They are bivalves attached by byssal threads (*Barbatia*, *Brachidontes*, and *Nayadina* (*Exputens*)); bivalves, brachiopods, and polychaete worms attached by cementation (*Spondylus*, *Ostrea*, *Craniscus*, and *Rotularia*); limpets and turbinid gastropods (*Erginus*, *Patelloida*?, *Diodora*, and *Homalopoma*); and brachiopods attached by a pedicle (*Gryphus*? and *Terebratulina*). In addition, two specimens of an encrusting colonial coral (*Leptastrea*?) are present.

Modern species of the byssate bivalves *Barbatia* and *Brachidontes* commonly live wedged in among rocks or colonial corals in intertidal or shallow subtidal waters (Stanley, 1970). *Nayadina* (*Exputens*) *batequensis* was interpreted to have been byssate and to have lived in shallow marine waters associated with reef corals (Squires, 1990a; Squires and Demetrion, 1992). This bivalve is the most common macrofossil in the upper Crescent Formation and 120 specimens were found at locality 1553. All specimens are disarticulated, but there are equal numbers of right and left valves indicating that the distance of postmortem transport was short. At locality 1554, an articulated specimen of this species was found.

Modern species of the bivalves *Spondylus* and *Ostrea* are commonly cemented to rocks, shells, and colonial corals in the intertidal zone and offshore in shallow subtidal depths (Keen, 1971; Abbott and Dance, 1982). *Spondylus carlosensis* is present at nearly every locality in the study area. At locality 1553, it is the second-most abundant macrofossil, and 60 specimens were found. All are free (non-cemented) valves, except for a single specimen of a left valve cemented to another *S. carlosensis*. Like *Spondylus*, the specimens of *Ostrea* are nearly all free valves. Only a single specimen of a cemented valve was found and it was attached to the brachiopod *Craniscus*. The near absence of the cemented valves of these types of bivalves indicates that they only rarely survived the erosion of the rocky substrate. A modern species of a similar craniacean brachiopod, *Neocrania californica* Berry, 1921, can be found cemented to rocky walls of glacially formed fjords in depths as shallow as 35

Table 1. Little River area macrofossil taxa reported for the first time from the Crescent Formation.

Hexactinellid sponge
 Aphrocallistes? sp.

Colonial coral
 ? *Leptastrea hertleini* Durham

Solitary corals
 Balanophyllia variabilis Nomland
 Trochocyathus crooki Merriam and Turner
 Turbinolia dickersoni Nomland

Inarticulate brachiopod
 Craniscus edwilsoni, new species

Articulate brachiopod
 Gryphus? sp.

Gastropods
 Calyptrea diegoana (Conrad)
 Colwellia sp.
 Conus sp.
 Dentimitra cretacea (Gabb)
 Diodora sp.
 Erginus vaderensis (Lindberg)
 Homalopoma sp. cf. *H. umpquaensis domenginensis*
 Vokes
 Homalopoma sp. aff. *H. wattsi* (Dickerson)
 Lyria andersoni Waring
 Patelloida? sp. cf. *P. vokesi* (Hickman)
 Patelloida? sp.
 Surculites mathewsonii (Gabb)
 Tenagodus bajaensis Squires
 Turritella andersoni Dickerson

Bivalves
 Acila (Truncacila) decisa (Conrad)
 Barbatia sp. aff. *B. (B.) landesi* (Weaver & Palmer)
 Brachidontes (B.) cowlitzensis (Weaver & Palmer)
 Corbula (Caryocorbula) dickersoni Weaver & Palmer
 Glycymeris (Glycymerita) sagittata (Gabb)
 Nayadina (Exputens) batequensis Squires
 Spondylus carlosensis Anderson

Barnacle
 Aporolepas sp.

Shark
 Isurus? sp.
 Palaeohypodotus sp.

m in northern British Columbia (Tunncliffe and Wilson, 1988). This modern species, which was formerly assigned to genus *Crania* Retzius, 1781, was recently reassigned by Lee and Brunton (1986) to genus *Neocrania* Lee and Brunton, 1986. Specimens of *Craniscus* were found only at locality 1553, and like the *Spondylus* and *Ostrea* specimens, nearly all are free (non-cemented) brachial valves. The polychaete worm *Rotularia* (*Rotularia*) is extinct but is a common component in shallow

marine Eocene deposits on the Pacific coast of North America (Squires, 1984, 1987, 1988a). Evidence for attachment for *Rotularia* (*R.*) *tejonense* is a specimen found attached to a pebble at locality 1553, and this specimen (showing the attachment scar) is illustrated in Figures 19 and 20.

Modern species of the limpets *Patelloida* and *Diodora* typically inhabit wave-swept rocky coasts (Keen, 1971; McLean, 1978). Modern species of *Erginus* live intertidally or subtidally (Lindberg, 1988). Most of the limpets found in the upper Crescent section are complete and those that possess radial ribbing are unabraded; therefore, the distance of postmortem transport had to have been short. Reports of limpet faunas are uncommon for the Paleogene of the Pacific coast of North America because shells of taxa from this high-energy environment rarely survive. As mentioned by Lindberg and Squires (1990), subtidal environments juxtaposed to rocky intertidal habitats provide a good preservational site for the limpets. Other gastropods in the upper Crescent Formation that lived on the pillow basalts are two species of the turbinid *Homalopoma*. Modern *Homalopoma* lives on hard substrates in intertidal and shallow subtidal depths (McLean, 1978).

The brachiopod *Terebratulina unguicula* is an extant species found from Kamchatka to San Diego on rocky bottoms in depths as shallow as 10 m (Hertlein and Grant, 1944). The species is common in glacially formed fjords in northern British Columbia and lives attached to rocky walls in depths less than 100 m where turbulent tidal action is present (Tunnicliffe and Wilson, 1988). Numerous single valves of *Terebratulina unguicula weaveri* were found at locality 1553, but only one articulated specimen was found. Little is known about the ecology of modern *Gryphus*, but species are known to inhabit deep waters near volcanic islands like the Galápagos Islands (Hertlein and Grant, 1944).

An entire 8-cm-long corallum of the colonial coral ?*Leptastrea hertleini* was found at locality 1553. This colonial coral may have also lived attached to the substrate because living species of *Leptastrea* commonly encrust in reef habitats in shallow tropical seas in the Indo-Pacific region and Red Sea area (Durham, 1942; Wood, 1983). *Leptastrea* is a hermatypic faviid colonial coral (Wells, 1956). Hermatypic corals are restricted to shallow waters by the light requirements of their symbiotic algae and flourish in depths less than 50 m (Britton and Morton, 1989).

There are some macrofossils in the Crescent Formation that could have lived among the rocky and shelly rubble deposited adjacent to the rocky surface of the basalt flows. They are sessile gastropods (*Calyptraea*), a cowrie-like gastropod (*Eratotrivia*), a small bivalve (*Corbula*), and sea urchins. Modern species of *Calyptraea* live attached to other shells and rocks in the intertidal zone and shallow subtidal depths (Keen, 1971). Trivid gastropods, similar to

the extinct *Eratotrivia*, are commonly found among rocky rubble intertidally and subtidally in warm waters (Abbott and Dance, 1982). Although most modern species of *Corbula* live offshore on sandy bottoms in relatively shallow waters, some live intertidally under rocks or among gravel and cling by means of a byssus (Keen, 1971). Modern sea urchins (cidaroids) prefer a hard bottom, such as rocks or shell debris (Fell, 1966). *Calyptraea* specimens are moderately common in the Crescent beds, but only a few specimens of *Eratotrivia* and *Corbula* were found. The sea urchin remains are quite common, consisting of only the spines and basal plates of spines, and the spines possess delicate spinelets that show no signs of abrasion.

Two capitular plates of the "gooseneck" barnacle *Aporolepas* were found at localities 1553 and 1554. This extinct genus is indicative of very shallow marine waters where it lived attached to hard substrate (V.A. Zullo, pers. comm., 1993).

Several specimens of the sessile gastropod *Tenagodus* were found at localities 1553 and 1553a. They may have lived embedded in sponges like certain modern species of *Tenagodus* that have been reported in the western Atlantic Ocean (Morton, 1955).

Some of the macrofossils in the sedimentary deposits were soft-substrate-dwelling mollusks, including the scaphopod (*Dentalium*), mobile gastropods (*Turritella*, *Lyria*, *Dentimitra*, *Surculites*, and *Conus*), and shallow-burrowing bivalves (*Acila*, *Glycymeris*, *Venericardia*, and *Nemocardium*). Nearly all of these genera are extant and have been reported from relatively shallow, offshore sandy to muddy bottoms (Abbott and Dance, 1982; Squires, 1984).

Additional soft-substrate-dwelling taxa in the Crescent Formation are the ahermatypic solitary corals *Flabellum*, *Trochocyathus*, and possibly *Balanophyllia*. Little is known about the living habits of most of the modern ahermatypic solitary corals, but *Flabellum* is usually found on muddy substrates, probably with the sharp base pushed deeper into the mud as the coral increases in size (Vaughan and Wells, 1943). Cairns (1989) reported a depth range of 22–2,300 m for modern species of *Flabellum* s.s. from the Philippine Islands and adjacent waters. Modern species of *Trochocyathus* have a similar depth range of 32–1,573 m (Vaughan and Wells, 1943) and probably live like *Flabellum*. Solitary corals are common at locality 1553, where they are mostly complete and have partial size series. The muddy matrix of the sandstone and the mudstones at this locality could have provided suitable soft substrate for these corals. The most abundant solitary coral at locality 1553, however, is *Balanophyllia*. Modern species can live on or under rocks in protected niches in the low intertidal zone where waves beat the hardest (Durham, 1947; Morris et al., 1980) or on soft substrates in depths to approximately 1,000 m (Vaughan and Wells, 1943). The *Balanophyllia* specimens at locality 1553 were

most likely transported from the nearby intertidal zone into the adjacent deeper, muddier waters.

Armentrout (1973) concluded that the macrofossils he found at his locality LR-1 (see also Armentrout, 1975), which is equivalent to CSUN 1553, are suggestive of a very shallow nearshore environment of perhaps less than 18 m. He based his interpretation on the presence of *Terebratulina*, *Acmaea*, *Turritella*, *Calyptraea*, *Barbatia*, and *Glycymeris* in the coarse sediment.

Benthic foraminifers from the microfossil sample at locality 1553 yielded an inner to middle neritic assemblage indicative of warm, clear water (H.L. Heitman, pers. comm., 1992). There are probable discocyclinid fragments in this sample, and these would indicate shallow marine conditions. Elsewhere in lower to middle Eocene strata along the Pacific coast of North America, specimens of discocyclinids have been found in nearshore to offshore, normal-salinity environments (Squires, 1984; Squires and Demettrion, 1992). Vaughan (1945) reported that discocyclinids are indicative of depths less than 100 m. Rau (1966) found the benthic foraminifers *Amphistegina*, *Quinqueloculina*, and certain *Cibicides* from locality 1553 and reported that they indicate possible reef conditions, perhaps in places less than 30 m in depth.

Locality 1553a represents the muddiest macrofossil deposit. It is a very thin deposit and not laterally extensive. Macrofossils are sparse and represent some of the substrate-attached species found farther downsection and a few small-sized, thin-shelled nuculanid? bivalve species found nowhere else in the section. According to Keen and Coan (1974), nuculanids are usually deep-water bivalves. The hexactinellid sponge *Aphrocallistes*? becomes more plentiful at locality 1553a. According to Rigby and Jenkins (1983), this type of sponge is common in deep waters. The macrofaunal assemblage at this locality is a mixture of storm-derived shallow marine species deposited with indigenous deep-water offshore species.

The depositional environment of the upper Crescent Formation in the Little River area is very similar to that in the upper Crescent Formation at Pulali Point in the eastern Olympic Peninsula, Washington. The Pulali Point area is approximately 70 km northeast of the Little River area (Fig. 1). At Pulali Point, the upper Crescent Formation contains pillow basalts interbedded with macrofossiliferous sedimentary rocks (Squires et al., 1992). Like the study area, the extrusion of each basalt unit at Pulali Point caused shoaling of the marine waters. Eroded rubble was transported a short distance into shallow subtidal depths. Living mostly among the basalt rubble were substrate-attaching species of bivalves (*Pododesmus* [see Squires, 1993] and *Ostrea*), rhynchonellid brachiopods (*Hemithiris*), and colonial corals. The solitary coral identified by Squires et al. (1992) as *Trochocyathus nomlandi* Bentson, 1943, from the upper Crescent Formation at Pulali Point is actually *Flabellum californicum* Vaughan, 1900,

which is also present in the upper Crescent Formation in the Little River area.

The depositional environment of the upper Crescent Formation in the Little River area also is similar to that in the lower Hamlet formation (informal name of Niem and Niem, 1985) in northwestern Oregon. The upper middle Eocene Roy Creek member of this formation at Rocky Point quarry consists of bouldery rubble derived from basaltic headlands and deposited in pocket beaches along a storm-dominated coastline (Mumford and Niem, 1992). Macrofossils are common and are dominated by substrate-attaching animals, including bivalves attached by byssal threads (*Barbatia*, *Pododesmus*, *Mytilus*, and *Septifer*), bivalves attached by cementation (*Ostrea*), limpets (*Acmaea*), sessile gastropods (*Calyptraea*), articulate brachiopods (*Rhynchonella* and "*Terebratula*"), and colonial corals (Warren and Norbistrath, 1946; Steere, 1957; Niem and Van Atta, 1973).

AGE

Sedimentary units in the upper Crescent Formation in the Little River area are middle early Eocene on the basis of macrofossils and benthic foraminifers. The most age-diagnostic macrofossils are *Turritella andersoni*, *Tenagodus bajaensis*, *Glycymeris* (*Tucetona*) *fresnoensis*, and *Nayadina* (*Exputens*) *batequensis*. They are known elsewhere from the Pacific coast of North America in strata that have been well documented as correlative with the provincial molluscan "Capay Stage" of middle early Eocene age (Vokes, 1939; Squires, 1984, 1987, 1988a, 1988b, 1990a, 1990b; Squires and Demettrion, 1992). Additional age-diagnostic macrofossils are *Leptastrea hertleini*, *Trochocyathus crooki*, and *Eratotrivia crescentensis*. They are not as well documented in their geologic ranges, but they have been reported elsewhere from the Pacific coast of North America in strata that would be considered by most workers to be correlative with the "Capay Stage" (Weaver and Palmer, 1922; Merriam and Turner, 1937; Durham, 1942; Bentson, 1943; Weaver, 1943).

On the basis of benthic foraminifers, Rau (1966, 1981) reported that the upper Crescent Formation in the Little River area is correlative to the Ulatisian Stage (as used by Mallory, 1959, and applied by Rau, 1981). Almgren et al. (1988) emended the age of this stage and showed that it is middle early Eocene through late early Eocene. Squires et al. (1992) illustrated how the Ulatisian Stage (in this emended sense) is equivalent to the upper part of the molluscan "Capay Stage" and to the lower part of the "Domengine Stage." The calcareous nanofossil assemblage from CSUN locality 1553 yielded long-ranging species that are only indicative of Eocene undifferentiated (M.V. Filewicz, pers. comm., 1992). The microfossil and macrofossil age determinations, therefore, indicate a middle early Eocene age (equivalent to the interval in which the

foraminiferal Ulatisian Stage, in the emended sense, and the molluscan "Capay Stage" overlap).

PALEOCLIMATE AND PALEOBIOGEOGRAPHY

Early Eocene time was the warmest interval of the Cenozoic, and tropical to subtropical conditions were widespread. Addicott (1970) reported that warm-water conditions existed at that time as far north as the Gulf of Alaska. There was no connection between the Arctic Ocean and the northeastern Pacific Ocean (Marincovich, 1992), and tropical macrofaunas inhabited areas as far north as the northern shore of the Olympic Peninsula (Durham, 1942, 1950).

The geographic dispersal of the Little River Crescent Formation's inarticulate brachiopod *Craniscus*, the bivalve *Nayadina* (*Exputens*) *batequensis*, and the shark *Paleohypotodus* was dramatically related to these early Eocene events. Previously, North American fossil craniacean brachiopods have been found only rarely in lower Tertiary rocks on the Atlantic and Gulf coasts of the United States, and their generic assignments have been tentative (Toulmin, 1940; Cooper, 1988). The presence of *Craniscus* in the upper Crescent Formation in the Little River area, therefore, is very significant. This is the first report of this genus from North America. Previously, it has been reported only from Europe, Japan, Australia, and the Indo-Pacific region (Lee and Brunton, 1986). It is likely that *Craniscus* reached the Pacific coast of North America by way of tropical currents that flowed westwardly from southern Europe and the Mediterranean region toward the New World. Squires (1987) discussed that the dispersal route of Old World (Tethyan) macroinvertebrate taxa was probably via a seaway in the southern Central American region.

Nayadina (*Exputens*) is a warm-water malleid bivalve with Old World Tethyan affinities, and *N. (E.) batequensis* is the earliest known species. Apparently, during the early Eocene it migrated westwardly from Jamaica (Squires, 1992) to Baja California Sur, Mexico (Squires, 1990a, 1992; Squires and Demetrian, 1992), and then northerly into the Little River area.

Additional evidence of migration of taxa from the Atlantic Ocean region into the Pacific coast of North America is the limpet *Diodora*, the "goose-neck" barnacle *Aporolepas*, and the shark *Palaeohypotodus*. The Little River specimens of *Diodora* are the earliest record of this genus from the Pacific coast of North America. Paleocene and other early Eocene records, however, are known from the southern and eastern United States (Palmer and Brann, 1966). *Aporolepas* is primarily known from western Europe and the Gulf coast of North America (Newman et al., 1969; V.A. Zullo, pers. comm., 1993). The shark *Palaeohypotodus* is a monotypic genus whose single species *P. rutoti* (Winkler, 1874) has been reported from Paleocene rocks in Green-

land, western Europe, Maryland, and North and South Dakota, as well as from lower Eocene rocks in western Europe (Cappetta, 1987; Ward and Wiest, 1990; Cvancara and Hoganson, 1993). Only a single tooth of this genus was found in the upper Crescent Formation, but it is well preserved and closely resembles *P. rutoti* Winkler.

Of the identified species reported for the first time from the Crescent Formation (Table 1), migration into the Little River area was mostly from the south based on their previously known geographic distribution (Nomland, 1916; Merriam and Turner, 1937; Vokes, 1939; Squires, 1984, 1987; Squires and Demetrian, 1992). The upper Crescent Formation in the Little River area is now the known northern limit of geographic distribution of most of these species. The exceptions are the bivalves *Acila* (*Truncacila*) *decisa*, *Brachidontes* (*B.*) *cowlitzensis*, and *Glycymeris* (*Glycymerita*) *sagittata*, whose northern limit of geographic distribution is in either Alaska or Russia (Devyatilova and Volobueva, 1981; Marincovich, 1988). These species may have emigrated southerly from Alaska or Russia into the Pacific coast region of North America.

The limpet gastropod *Erginus vaderensis* has not been found farther south than the upper Eocene "Gries Ranch beds" of the Lincoln Creek Formation in southwestern Washington, and the modern distribution of the genus is throughout the boreal Pacific Ocean, Arctic Ocean, and North Atlantic Ocean (Lindberg, 1988). *Erginus vaderensis* is another one of the Little River Crescent Formation species that may have originated in northern latitudes and then migrated to the south. The Little River area specimens of this gastropod are the earliest record of this genus.

SYSTEMATIC MATERIALS AND METHODS

Synonymies, primary type material, molluscan stage range, geographic distribution, local occurrence, and remarks are listed for species/subspecies. Terms used to denote specimen abundance are defined as follows (number or specimens in parentheses): rare (1–4), uncommon (5–9), common (10–29), and abundant (30 or more).

Abbreviations for catalog and/or locality numbers are as follows:

- ANSP: Academy of Natural Sciences, Philadelphia.
- CAS: California Academy of Sciences, San Francisco.
- CSUN: California State University, Northridge.
- IGM: Instituto de Geología, Universidad Nacional Autónoma de México, Mexico City.
- LACMIP: Natural History Museum of Los Angeles County, Invertebrate Paleontology Section.
- LACMVP: Natural History Museum of Los Angeles County, Vertebrate Paleontology Section.
- SU: Stanford University (collections now housed at the California Academy of Sciences).
- UCMP: University of California, Museum of Paleontology, Berkeley.
- USNM: National Museum of Natural History, Washington, D.C.
- UW: University of Washington, Seattle.

The bulk of the Little River area macrofossil collection is housed at CSUN. New species primary type material and hypotypes of the invertebrates used for illustrations in this report are deposited at LACMIP. The shark-teeth hypotypes are deposited at LACMVP.

SYSTEMATICS

Phylum Porifera Grant, 1861

Class Hexactinellida
Schmidt, 1870

Family Aphrocallistidae
Gray, 1867

Genus *Aphrocallistes* Gray, 1858

Aphrocallistes? sp.
Figure 4

ILLUSTRATED SPECIMEN. LACMIP hypotype 12220.

LOCAL OCCURRENCE. CSUN locs. 1553, 1553a.

REMARKS. Specimens are uncommon at locality 1553a and rare at locality 1553. Preservation of the sheet-like or knobby fragments is as internal molds. Walls of the specimens, which are less than 7 mm in length, show a honeycomb-like, polygonal pattern like the morphology of *Aphrocallistes*. Preservation is too poor to allow positive identification to genus.

If the Little River area specimens of *Aphrocallistes?* eventually do prove to be *Aphrocallistes*, they would be the earliest record of this genus on the Pacific coast of North America. Previously, *Aphrocallistes* has been reported by Rigby and Jenkins (1983) from upper Eocene to Miocene rocks of southwestern Washington. It has not been previously reported from the Crescent Formation.

Phylum Cnidaria Hatschek, 1888

Class Anthozoa Ehrenberg, 1834

Order Scleractinia Bourne, 1900

Family Faviidae Gregory, 1900

Genus *Leptastrea*
Milne Edwards and Haime, 1848

?*Leptastrea hertleini*
Durham, 1942
Figure 5

Leptastrea hertleini Durham, 1942:507, pl. 44, figs. 1, 4, 5.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12201.

LOCAL OCCURRENCE. CSUN loc. 1553.

REMARKS. Two specimens were found. The largest one, which is figured, is an entire colony whose diameter is 80 mm. The massive and flattened corallum resembles *L. hertleini*, known only

from lower Eocene rocks in Media Agua Creek, Temblor Range, southwestern San Joaquin Valley, south central California.

Family Caryophyllidae Gray, 1847a

Genus *Turbinolia* Lamarck, 1816

Turbinolia dickersoni
Nomland, 1916
Figures 6, 7

Turbinolia dickersoni Nomland, 1916:61, pl. 3, figs. 5–8. Palmer, 1923:306, pl. 56, figs. 2, 4. Quayle, 1932:98–99, pl. 6, figs. 1–5. Squires, 1984:15, figs. 5d, e; 1991:pl. 1, figs. 2–3. Squires and Demettrion, 1992:24, figs. 45, 46.

PRIMARY TYPE MATERIAL. UCMP holotype 12020 (missing since 1932), Cerros Shale Member of the Lodo Formation, UCMP loc. 1817.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12202.

MOLLUSCAN STAGE RANGE. Upper Paleocene through “Domengine.”

GEOGRAPHIC RANGE. Eastern Laguna San Ignacio area, Baja California Sur, Mexico, to Little River area, Washington.

LOCAL OCCURRENCE. CSUN loc. 1557.

REMARKS. Only a single specimen was found and it is the first record of this minute species from the Crescent Formation and from Washington. Previously, the northern limit of this species was Vacaville, northern California (Palmer, 1923).

Genus *Trochocyathus*
Milne-Edwards and Haime, 1848

Trochocyathus crooki
Merriam and Turner, 1937
Figure 8

Trochocyathus crooki Merriam and Turner, 1937:106, pl. 5, figs. 7–9. Bentson, 1943:293, pl. 50, figs. 12–14.

PRIMARY TYPE MATERIAL. UCMP holotype 33697; UCMP paratypes 3396, 3398; all from UCMP loc. A-1315.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12203.

MOLLUSCAN STAGE RANGE. “Capay.”

GEOGRAPHIC RANGE. West side of Sacramento Valley, northern California to Little River area, Washington.

LOCAL OCCURRENCE. CSUN loc. 1553.

REMARKS. Specimens are common, mostly complete, and range in height from 6 to 16 mm. This is the first report of this solitary coral from the Crescent Formation and from Washington. Previously, the northern limit of this species was the Guinda area, northern California (Merriam and Turner, 1937; Bentson, 1943).

Family Flabellidae Bourne, 1905

Genus *Flabellum* Lesson, 1831

Flabellum californicum

Vaughan, 1900

Figures 9, 10

Flabellum californicum Vaughan, 1900:69, pl. 4, figs. 11–12. Nomland, 1916:60, pl. 4, figs. 14–16. Durham, 1943:196.

?*Trochocyathus nomlandi* Bentson. Squires et al., 1992:pl. 1, figs. 1–2. Not *Trochocyathus nomlandi* Bentson, 1943.

PRIMARY TYPE MATERIAL. Specimens at USNM, type locality is 4 km (2.5 mi.) northeast of Clayton, Contra Costa County, northern California.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12204.

MOLLUSCAN STAGE RANGE. “Capay” through “Domengine.”

GEOGRAPHIC RANGE. Contra Costa County, northern California to Pulali Point, Washington.

LOCAL OCCURRENCE. CSUN locs. 1553, 1555.

REMARKS. This distinctly cuneiform species is common at locality 1553 and rare at locality 1555. Specimens are mostly complete and approximately 9 mm in height. Durham (1943) assigned the rocks at the type locality of this species to the “Domengine Stage.”

Family Dendrophylliidae

Gray, 1847a

Genus *Balanophyllia* Wood, 1844

Balanophyllia variabilis

Nomland, 1916

Figure 11

Balanophyllia variabilis Nomland, 1916:66, pl. 4, figs. 2–3, 4, 13.

Balanophyllia variabilis Nomland var. Merriam and Turner, 1937:101, 106, pl. 5, figs. 12–13.

PRIMARY TYPE MATERIAL. Specimens at UCMP, Mount Diablo region, Contra Costa County, northern California, UCMP loc. 714.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12205.

MOLLUSCAN STAGE RANGE. “Capay” through “Domengine.”

GEOGRAPHIC RANGE. Northern California to Little River area, Washington.

LOCAL OCCURRENCE. CSUN loc. 1553.

REMARKS. Specimens are abundant and many are complete. There is a partial growth size series with specimens ranging from 13 to 23 mm in height.

This is the first report of this species from the Crescent Formation and from Washington. Previously, the northern limit of this species was the Guinda area, northern California (Nomland, 1916; Merriam and Turner, 1937). Merriam and Turner (1937) assigned the rocks at the type locality of this species to the “Domengine Stage.”

Phylum Brachiopoda Duméril, 1806

Class Inarticulata Huxley, 1869

Order Craniidina Waagen, 1885

Family Craniidae Menke, 1828

Genus *Craniscus* Dall, 1871

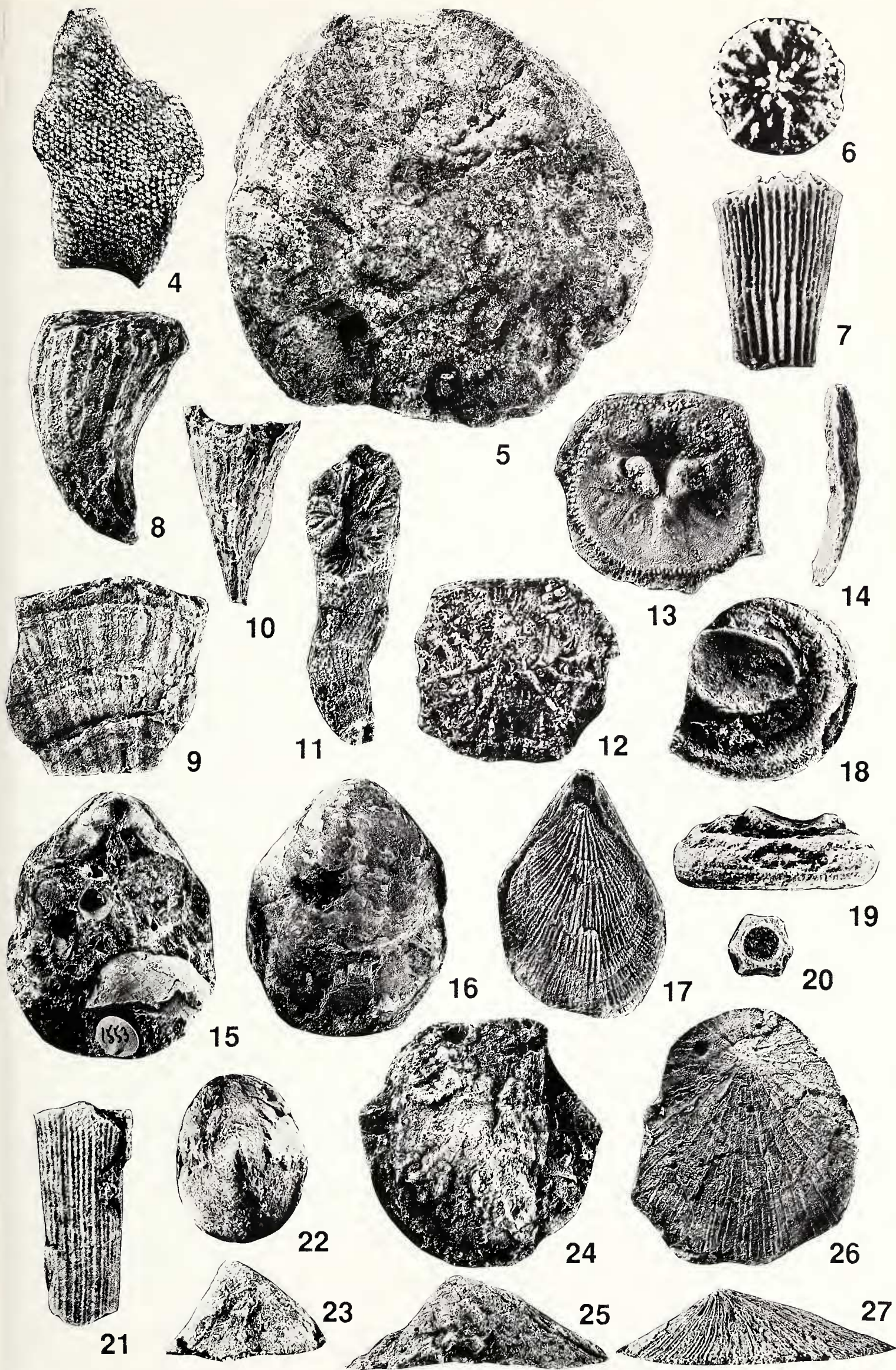
Craniscus edwilsoni,
new species

Figures 12, 13, 14

DIAGNOSIS. Brachial valve with widely spaced radial ribs, apex slightly posterior of center, a well-delimited tripartite interior with a minutely pustulose flattened margin.

COMPARISON. Compared to other brachio-

→
Figures 4–27. Little River area upper Crescent Formation, sponge, colonial coral, solitary corals, inarticulate brachiopod, articulate brachiopods, polychaete worm, scaphopod, and gastropods. CSUN loc. 1553 unless otherwise noted. All specimens coated with ammonium chloride. 4. Sponge. *Aphrocallistes?* sp., $\times 3.5$, LACMIP hypotype 12200. 5. Colonial coral. ?*Leptastrea hertleini* Durham, 1942, basal view of corallum, $\times 0.9$, LACMIP hypotype 12201. 6–11. Solitary corals. 6, 7. *Turbinolia dickersoni* Nomland, 1916, $\times 7$, LACMIP hypotype 12202, CSUN loc. 1557. 6. Dorsal view. 7. Lateral view. 8. *Trochocyathus crooki* Merriam and Turner, 1937, lateral view, $\times 3.3$, LACMIP hypotype 12203. 9, 10. *Flabellum californicum* Vaughan, 1900, $\times 3.3$, LACMIP hypotype 12204. 9. Lateral view. 10. End view. 11. *Balanophyllia variabilis* Nomland, 1916, lateral view, $\times 2$, LACMIP hypotype 12205. 12–14. Inarticulate brachiopod. *Craniscus edwilsoni*, new species, $\times 4.3$, LACMIP holotype 12206. 12. Exterior view. 13. Interior view. 14. Side view. 15–17. Articulate brachiopods. 15, 16. *Gryphus?* sp., pedicle valve, $\times 1.1$, LACMIP hypotype 12212. 15. Interior view. 16. Exterior view. 17. *Terebratulina unguicula weaveri* Hertlein and Grant, 1944, dorsal view, $\times 2.8$, LACMIP hypotype 12213. 18–20. Polychaete worm. *Rotularia* (*Rotularia*) *tejonense* (Arnold, 1910). 18, 19. $\times 5$, LACMIP hypotype 12214. 18. Umbilical view (showing attachment scar). 19. Lateral view. 20. End view, $\times 4$, LACMIP hypotype 12215. 21. Scaphopod. *Dentalium* sp. lateral view, partial specimen, $\times 7.3$, LACMIP hypotype 12216. 22–27. Gastropods. 22, 23. *Erginus vaderensis* (Lindberg, 1979), internal mold, $\times 4$, LACMIP hypotype 12217. 22. Dorsal view. 23. Left-profile view. 24, 25. *Patelloida?* sp. cf. *P. vokesi* (Hickman, 1980), internal mold, $\times 2.9$, LACMIP hypotype 12218. 24. Dorsal view. 25. Left-profile view. 26, 27. *Patelloida?* sp., CSUN loc. 1555. 26. Rubber cast of external mold, dorsal view, $\times 2.9$, LACMIP hypotype 12219. 27. Internal mold, left-profile view, $\times 2.8$, LACMIP hypotype 12220.



pod genera, craniacean genera have undergone few major revisions in the past two centuries. Lee and Brunton (1986) recently reviewed and updated the genera in family Craniidae. Using their new diagnoses and descriptions of the genera, we can assign the Little River area craniacean species to genus *Craniscus* Dall, 1871. The type species of *Craniscus*, the Late Jurassic *Crania tripartita* Münster (in Goldfuss, 1840) from Germany, is unusual in that it has thin, wall-like septa in the interior of the brachial valve that divide the interior into three chambers. Other species of *Craniscus* have an internal tripartite subdivision without the thin, wall-like septa.

Craniscus edwilsoni, new species, was compared to the few known species of *Craniscus* and is most similar to certain specimens of *C. skeatsi* (Allan, 1940) illustrated by Archbold (1990:figs. 2I, 2L, 2N). *Craniscus skeatsi* is known from upper Oligocene to lower Miocene rocks in southeastern Australia (Archbold, 1990). The new species differs from *C. skeatsi* in having a brachial valve with radial ribbing, a more distinct tripartite interior, more elevated and more diverging anterior adductor pedestals, and a pustulose limbus.

Only a few craniacean species have been reported from the Paleogene of North America, and they are all unnamed species tentatively assigned to genera. Toulmin (1940) reported a single unnamed species of *Crania*? from the lower Eocene Salt Mountain Limestone of Alabama, and Cooper (1988) reported two unnamed species of *Crania*? from the predominantly middle Eocene Castle Hayne Formation of North Carolina. Cooper (1988) also reported two unnamed species of *Isocrania*? from the middle Eocene Santee Formation of South Carolina and another unnamed species of *Isocrania*? from the Oligocene Cooper Formation of South Carolina.

The new species has close affinity to *Crania*? sp. 1 Cooper (1988:5, figs. 4–6), from the Castle Hayne Formation of North Carolina, but differs in having a brachial valve with a more centrally located apex, fewer and much coarser radial ribs, and a more elongate anteromedian ridge. The new species also has close affinity to *Isocrania*? sp. 2 Cooper (1988:5, pl. 3, figs. 9, 10; pl. 6, figs. 2, 3), from the Oligocene Cooper Formation of South Carolina, but differs in having a less pointed apex, fewer radial ribs, a more prominent anteromedian ridge, and a better developed pustulose limbus.

The new species differs from the other unnamed species of Cooper (1988) in having much more swollen anterior adductor pedestals, the presence of an anteromedian ridge, and a less ribbed exterior.

Craniscus edwilsoni resembles Toulmin's (1940:228, pl. 28, figs. 1–3; Stenzel, 1942:card no. 122, figs. 1–3) *Crania*? sp., from the lower Eocene Salt Mountain Limestone of Alabama, but differs in having a brachial valve with non-spinose radial ribs, a more prominent ridge around the interior of the valve, more pronounced posterior adductor ped-

estals, and apparently a more elongate anteromedian ridge. The anteromedian ridge region in the Salt Mountain species is incomplete, but it appears to be less elongate and less raised than the new species.

Lee and Brunton (1986) reported that genus *Crania* Retzius, 1781, is restricted to the Upper Cretaceous (Campanian–Maastrichtian) and that *Isocrania* Jaekel, 1902, is restricted to the Upper Cretaceous to lower Tertiary (Campanian–Danian). The unnamed Eocene species of *Crania*? discussed by Toulmin (1940) and the unnamed Paleogene species of *Crania*? and *Isocrania*? discussed by Cooper (1988), therefore, should be reevaluated systematically.

Toulmin's (1940) *Crania*? sp. and Cooper's (1988) *Crania*? sp. 1 and *Isocrania*? sp. 2 closely resemble *Craniscus edwilsoni*, new species, and should be assigned to genus *Craniscus*. Their species, along with *Craniscus edwilsoni*, however, differ from other species of *Craniscus* by possessing a pustulose limbus like that seen in the genera *Crania* and *Isocrania*. With more study, these particular species of Toulmin and Cooper and the new species may prove to be a distinct subgenus of *Craniscus*.

DESCRIPTION. Brachial valve small (up to 12 mm wide), circular, flattened to moderately inflated. Raised apex slightly posterior of center. Surface marked by 10–20 thin, radial riblets separated by wide spaces. Radial ribs tend to be much finer along posterior margin. Interior marked on posterior margin by moderately raised posterior adductor pedestals. Anterior adductor pedestals near center of valve consisting of two short oblique elevations diverging posteriorly with V-shaped depression between them. Anteromedian ridge [= median myophore] moderately raised and extending anteriorly from the anterior adductor pedestals to slightly anterior of midvalve. Anterior adductor pedestals and anteromedian ridge divide valve into three sections or chambers. Inner margins of brachial valve flattened [= limbus] and pustulose. Pedicle valve not found.

HOLOTYPE. 7 mm wide, 6.5 mm long, 1 mm high.

PRIMARY TYPE MATERIAL. LACMIP holotype, 12206 (illustrated), LACMIP paratypes 12207 to 12211; all from CSUN loc. 1553.

TYPE LOCALITY. CSUN loc. 1553.

MOLLUSCAN STAGE RANGE. "Capay."

GEOGRAPHIC RANGE. Larch Mountain and Rock Candy Mountain in the Black Hills area, and Little River area, Washington.

LOCAL OCCURRENCE. CSUN loc. 1553.

REMARKS. Specimens are common at the type locality, and most are unbroken single valves. A few brachial valves are fairly thick and smooth, apparently because of abrasion.

Ongoing work by us has revealed rare specimens of the new species from the upper Crescent Formation in the vicinity of Larch Mountain (CSUN loc. 1563) and in the vicinity of Rock Candy Moun-

tain (CSUN loc. 1564), Black Hills area (Fig. 1), about 50 km southeast of the Little River area.

According to Rowell (1965), *Craniscus* is a cosmopolitan genus whose geologic range is Jurassic to Recent. Lee and Brunton (1986), however, restricted the geographic distribution of the genus to Europe, Australia, Japan, and the Indo-Pacific area.

The specimens of *Craniscus edwilsoni* in the upper Crescent Formation in the Little River and Black Hills areas, Washington, are the first record of *Craniscus* from the Pacific coast of North America and the first named species of this genus in the New World.

ETYMOLOGY. The new species is named after Edward C. Wilson, Curator, Invertebrate Paleontology Section, Natural History Museum of Los Angeles County, who has made valuable contributions to the study of invertebrate paleontology.

Class Articulata Huxley, 1869

Family Terebratulidae Gray, 1840

Genus *Gryphus*

Megerle von Mühlfeld, 1811

Gryphus? sp.

Figures 15, 16

ILLUSTRATED SPECIMEN. LACMIP hypotype 12212.

LOCAL OCCURRENCE. CSUN locs. 1553, 1554.

REMARKS. Specimens are common at locality 1553 but are rare at locality 1554. All specimens are single valves and at locality 1553 they are up to 40 mm in length. Preservation is too poor to allow generic identification.

Family Cancellothyrididae

Thomson, 1926

Genus *Terebratulina*

d'Orbigny, 1847

Terebratulina unguicula weaveri

Hertlein and Grant, 1944

Figure 17

Terebratulina unguicula Carpenter var. B. Weaver, 1943:15, pl. 1, fig. 11.

Terebratulina unguicula weaveri Hertlein and Grant, 1944:81–83, pl. 6, figs. 4–5, 8–9, text fig. 20. Squires et al., 1992:pl. 1, figs. 6–8.

PRIMARY TYPE MATERIAL. CAS holotype 7303, upper Crescent Formation, Jefferson County, Washington, UW loc. 353.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12213.

MOLLUSCAN STAGE RANGE. “Capay” to approximately the “Capay”/“Domengine” boundary.

GEOGRAPHIC RANGE. Black Hills area, Little River area, Pulali Point, and Quilcene, Washington.

LOCAL OCCURRENCE. CSUN locs. 1553, 1554, 1555, 1559.

REMARKS. Specimens are abundant at locality 1553 where they range in size from 6 to 20 mm in length. Only one specimen from this locality is articulated. A few fragmental specimens were found at locality 1554 and specimens are rare at the other localities where fragments were found also.

Squires (1992) discussed the age of the type locality of this species and assigned it to near the “Capay Stage”/“Domengine Stage” boundary.

Phylum Annelida Lamarck, 1809

Class Polychaeta Grube, 1850

Order Sabellida Malmgren, 1867

Family Serpulidae Johnston, 1865

Genus *Rotularia* Defrance, 1827

Subgenus *Rotularia* s.s.

Rotularia (Rotularia) tejonense

(Arnold, 1910)

Figures 18, 19, 20

Spiroglyphus? tejonense Arnold, 1910:51, pl. 4, fig. 18. Dickerson, 1916:pl. 37, figs. 5a–b. Vokes, 1939:162–163, pl. 20, figs. 20–22. Stewart, 1946:pl. 11, fig. 21.

Spiroglyphus? capayensis Merriam and Turner, 1937:106, pl. 5, figs. 10, 11.

Spiroglyphus tejonensis Arnold. Hanna and Hertlein, 1941:figs. 62–4, 62–20.

?*Tubulostium capayense* (Merriam and Turner). Keen and Bentson, 1944:195.

?*Tubulostium tejonense* (Arnold). Keen and Bentson, 1944:195.

Rotularia tejonense (Arnold). Nilsen, 1973:table 1. Squires, 1977:table 1; 1984:15, fig. 5g.

Rotularia (Rotularia) tejonense (Arnold). Squires, 1987:19, 21, figs. 7, 8; 1988a:8, figs. 5, 6. Squires et al., 1992:pl. 1, figs. 12, 13.

PRIMARY TYPE MATERIAL. USNM holotype 165658 of *Spiroglyphus? tejonense*, Avenal Sandstone, Kings County, California, USGS loc. 4617. UCMP holotype 33700 and UCMP paratype 33699 of *Spiroglyphus? capayensis*, Capay Formation, Capay Valley, California, UCMP loc. A-1313.

ILLUSTRATED SPECIMENS. LACMIP hypotypes 12214–12215.

MOLLUSCAN STAGE RANGE. “Capay” through “Transition.”

GEOGRAPHIC RANGE. Simi Valley, southern California to Pulali Point, Washington.

LOCAL OCCURRENCE. CSUN locs. 1553, 1553a, 1554, 1556, 1560.

REMARKS. A few specimens were found at locality 1553. At the other localities, specimens are rare. Most specimens are coiled, but a few are fairly long, straight fragments. One specimen, which is

figured, was attached to a small pebble, and the attachment scar is very prominent.

As noted by Vokes (1939), the holotype of *R. (R.) tejonense* is not representative of the ordinary forms in this very variable species. We agree with Vokes' (1939) comment that "the ordinary forms are inclined to be hexagonal in section, with a prominent sulcation on either side of a prominent median ridge on both top and bottom of the whorl, and with two minor sulcations on the outer edge."

Merriam and Turner (1937) reported *Spriglyphus? capayensis* Merriam and Turner from the lower Eocene of northern California and southwestern Oregon, as well as from the middle Eocene of central California and southwestern Oregon. Their species is herein regarded as conspecific with *R. (R.) tejonense*.

Phylum Mollusca Linné, 1758

Class Scaphopoda Bronn
(in Bronn and Keferstein, 1862)

Order Dentalioida Palmer, 1974

Family Dentaliidae Gray, 1834

Genus *Dentalium* Linné, 1758

Dentalium sp.

Figure 21

ILLUSTRATED SPECIMEN. LACMIP hypotype 12216.

LOCAL OCCURRENCE. CSUN locs. 1553, 1554, 1559.

REMARKS. A few specimens were found at locality 1553. At the other localities specimens are rare. Specimens are small-sized fragments. More complete specimens are needed to identify the species.

Class Gastropoda Cuvier, 1797

Order Patellogastropoda
Lindberg, 1986

Family Lottiidae Gray, 1840

Genus *Erginus* Jeffreys, 1877

Erginus vaderensis
(Lindberg, 1979)

Figures 22, 23

Acmaea simplex Dickerson, 1917:181, pl. 31, figs. 11a-b. [Not *Acmaea cubensis simplex* Pilsbry, 1891:42.]

Acmaea clarki Van Winkle. Effinger, 1938:374. Weaver, 1943:282. [Not *Acmaea clarki* Van Winkle, 1918:85, pl. 6, fig. 4.]

Acmaea vaderensis Lindberg, 1979:223 [nom. nov.]. *Erginus vaderensis* (Lindberg). Lindberg, 1988:5, pl. 1E-G.

PRIMARY TYPE MATERIAL. CAS holotype

438, "Gries Ranch beds" of the Lincoln Creek Formation, Lewis County, Washington, CAS loc. 181.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12217.

MOLLUSCAN STAGE RANGE. "Capay" through "Tejon."

GEOGRAPHIC RANGE. Vader, Porter Creek (Grays Harbor County), Discovery Bay (Jefferson County), and Little River area, Washington.

LOCAL OCCURRENCE. CSUN locs. 1553, 1554, 1555, 1557.

REMARKS. A few specimens were found at localities 1553 and 1555. At the other localities, specimens are rare. Preservation is mostly as internal molds, but a few specimens have some shell. The shell profile is high with the apex at one-third of length from the anterior end. The shell is smooth except for minute growth lines. The Little River specimens are late juveniles about 5 mm in length. According to Lindberg (1988), shell length in this species can be up to about 9 mm.

The Little River area specimens of *Erginus vaderensis* are the earliest record of both this genus and species and the first record of them from the Crescent Formation. Previously, *E. vaderensis* has been reported only from Washington and only from the upper Eocene part of the Lincoln Creek Formation (including the "Gries Ranch beds") and the Quimper Sandstone (Lindberg, 1988).

Genus *Patelloida*

Quoy and Gaimard, 1834

Patelloida? sp. cf. *P. vokesi*
(Hickman, 1980)

Figures 24, 25

Acmaea vokesi Hickman, 1980:14-15, pl. 1, figs. 1-4.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12218.

LOCAL OCCURRENCE. CSUN locs. 1553, 1554, 1555, 1560.

REMARKS. A few specimens were found at locality 1553. At the other localities, specimens are rare. Specimens are mostly molds. They closely resemble *Patelloida vokesi* (Hickman, 1980) from the upper Eocene Keasey Formation in northwestern Oregon. Preservation is too poor to allow positive identification of the Little River specimens. If these eventually do prove to be *Patelloida*, they would be the earliest record of this genus from the Pacific coast of North America. The earliest undoubted report of this genus from this area are two species from middle Eocene rocks in the Tehachapi Mountains, southern California (Lindberg and Squires, 1990).

Patelloida? sp.

Figures 26, 27

ILLUSTRATED SPECIMENS. LACMIP hypotype 12219-12220.

LOCAL OCCURRENCE. CSUN locs. 1555, 1557, 1560.

REMARKS. Specimens are rare and are molds. The low profile and radial sculpture evidence suggest assignment to the genus *Patelloida*, but preservation is too poor to allow positive identification. *Patelloida*? sp. has many more and finer ribs than *Patelloida*? sp. cf. *P. vokesi*, also from the Little River area. As mentioned above, the earliest undoubted report of *Patelloida* from the Pacific coast of North America is middle Eocene from southern California.

Order Vetigastropoda
Salvini-Plawén, 1980

Family Fissurellidae
Fleming, 1822

Genus *Diodora* Gray, 1821

Diodora sp.
Figure 28

ILLUSTRATED SPECIMEN. LACMIP hypotype 12221.

LOCAL OCCURRENCE. CSUN locs. 1553, 1554, 1555.

REMARKS. A few specimens were found at locality 1553. At the other localities, specimens are rare. Specimens are either internal molds or interiors of shells. They show evidence of a truncate internal callus, which is the main diagnostic feature of genus *Diodora*. Preservation is too poor to allow identification as to species. A few specimens show evidence of reticulate ornamentation that resembles *Diodora stillwaterensis* (Weaver and Palmer, 1922:27, pl. 11, figs. 3, 6) known from the upper middle Eocene Cowlitz Formation, southwestern Washington (Weaver, 1943), and possibly from the middle Eocene ("Transition Stage") Friars Formation, San Diego County, southern California (Squires and Deméré, 1991). *Diodora stillwaterensis* is the only previously reported *Diodora* from the Eocene of the Pacific coast of North America. The Little River area specimens of *Diodora* are the earliest occurrence of this genus on the Pacific coast of North America and the first occurrence of this genus from the Crescent Formation. Paleocene and early Eocene reports of this genus from elsewhere in the United States are confined to Maryland, Alabama, and Mississippi (Palmer and Brann, 1966).

Family Turbinidae Rafinesque, 1815

Genus *Homalopoma* Carpenter, 1864

Homalopoma sp. cf.
H. umpquaensis domenginensis
Vokes, 1939
Figures 29, 30

Homalopoma umpquaensis domenginensis Vokes, 1939:179–180, pl. 22, fig. 27.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12222.

LOCAL OCCURRENCE. CSUN locs. 1553, 1554.

REMARKS. Specimens are abundant at locality 1553 and rare at locality 1554. Nearly all the specimens are fragments. Preservation is too poor to allow positive identification as to species. Although the illustrated specimen is worn, the nodes on the body whorl spirals are fairly prominent.

This is the first report of genus *Homalopoma* from the Crescent Formation. If the Little River area specimens eventually prove to be *H. umpquaensis domenginensis* Vokes, 1939, they would be the first occurrence of this subspecies in Washington and in the Crescent Formation. The northern limit of this subspecies is presently central California (Squires, 1988a).

Homalopoma sp. aff. *H. watti*
(Dickerson, 1916)
Figures 31, 32

Monodonta watti Dickerson, 1916:494, pl. 40, figs. 3a, 3b.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12223.

LOCAL OCCURRENCE. CSUN loc. 1555.

REMARKS. Specimens are rare. They resemble *Homalopoma watti* (Dickerson, 1916), reported (Weaver, 1943) from lower Eocene strata in California and southwestern Washington. The Crescent Formation specimen, like *H. watti*, has many spiral ribs and two nodes on the inner lip. The Crescent Formation specimens differ from *H. watti* in the following features: somewhat finer spiral ribs and no tendency for those in the middle part of the body whorl to be coarser than the others.

The Crescent Formation specimens of *Homalopoma* sp. aff. *H. watti* are very similar to specimens of *H. aff. H. watti* reported (Squires, 1991: pl. 1, fig. 9) from "Capay Stage" strata in the Orocochia Mountains, southern California.

Order Caenogastropoda Cox, 1960

Family Turritellidae Woodward, 1851

Genus *Turritella* Lamarck, 1799

Turritella andersoni s.s. Dickerson, 1916
Figure 33

Turritella andersoni Dickerson, 1916:501–502, pl. 42, fig. 9a, b. Turner, 1938:83, pl. 22, figs. 4–6. Merriam, 1941:76–77, pl. 9, figs. 1–2; pl. 10, figs. 1, 3–5, 8; pl. 12, figs. 1–3. Hanna and Hertlein, 1941:figs. 62–6, 62–7, 62–16. Givens, 1974:62, pl. 5, figs. 7–10. Squires, 1984:16–17, fig. 6e; 1987:24–25, figs. 20–21; 1988a:10, fig. 14; 1988b:205, fig. 2; 1988c:pl. 1, fig. 2; 1991:pl. 1, fig. 12. Squires and Demetron, 1992:26, fig. 58.

Turritella andersoni susanae Merriam, 1941:79, pl. 11, fig. 6. Saul, 1983:pl. 2, fig. 5.

PRIMARY TYPE MATERIAL. UCMP holotype 12131, UCMP paratype 12132, both missing since 1959, Cerros Shale Member of Lodo Formation, Fresno County, California, UCMP loc. 1817; UCMP neotype 38193 (designated by Squires, 1988c), UCMP loc. 1817.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12224.

MOLLUSCAN STAGE RANGE. "Capay."

GEOGRAPHIC RANGE. Eastern Laguna San Ignacio area, Baja California Sur, Mexico, to Little River area, Washington.

LOCAL OCCURRENCE. CSUN loc. 1553.

REMARKS. Specimens are abundant, well-preserved small fragments showing the diagnostic whorl profile that is broadly concave medially between a pair of broadly spaced primary spiral ribs.

This is the first report of this species from Washington. Previously, *T. andersoni* had been reported as far north as southwestern Oregon (Turner, 1938; Squires and Demetron, 1992). Weaver (1937) reported this species from the Metchosin Volcanics near Victoria, British Columbia, in rocks that have been correlated with the Crescent Formation (Muller, 1980), but the specimens belong to a different species (Squires, 1988b).

Family Siliquariidae Anton, 1838

Genus *Tenagodus* Guettard, 1770

Tenagodus bajaensis

Squires, 1990b

Figures 34, 35

Tenagodus bajaensis Squires, 1990b:298, figs. 6–8.
Squires and Demetron, 1992:27–28, fig. 64.

PRIMARY TYPE MATERIAL. IGM holotype 5102, IGM paratype 5103, Bateque Formation, eastern Laguna San Ignacio area, Baja California Sur, Mexico, CSUN loc. 1291a.

ILLUSTRATED SPECIMENS. LACMIP hypotype 12225–12226.

MOLLUSCAN STAGE RANGE. "Capay."

GEOGRAPHIC RANGE. Eastern Laguna San Ignacio area, Baja California Sur, Mexico, to Little River area, Washington.

LOCAL OCCURRENCE. CSUN locs. 1553, 1553a.

REMARKS. Specimens are rare and the shell material easily falls off leaving only internal molds. Most specimens show the slit that is so characteristic of this genus.

This is the first report of this species from the Crescent Formation and from Washington. Previously, it had only been found in the "Capay Stage" part of the Bateque Formation, eastern Laguna San Ignacio area, Baja California Sur, Mexico (Squires, 1990b; Squires and Demetron, 1992).

Family Calyptraeidae Blainville, 1824

Genus *Calyptraea* Lamarck, 1799

Calyptraea diegoana (Conrad, 1855)

Figure 36

Trochita diegoana Conrad, 1855:7, 17; 1857:327, pl. 5, fig. 42.

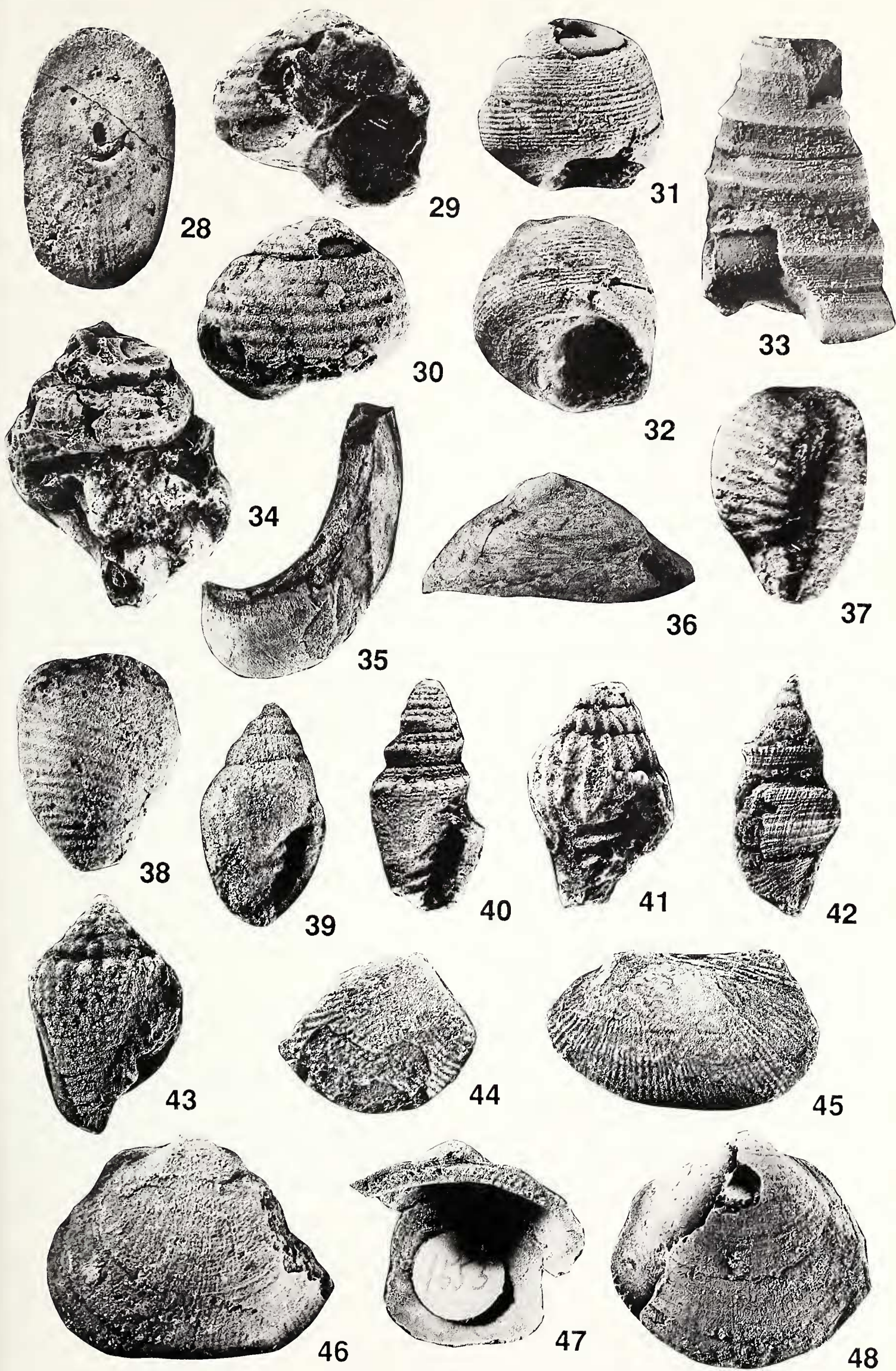
Galerus excentricus Gabb, 1964:136, pl. 20, fig. 95; pl. 29, fig. 232a. Dickerson, 1913:264.

Calyptraea calabasaensis Nelson, 1925:419, pl. 54, figs. 8a–b.

Calyptraea (*Galerus*) *calabasaensis* Nelson. Clark and Woodford, 1927:120, pl. 21, figs. 10–13.

Calyptraea diegoana (Conrad). Stewart, 1927:340–341, pl. 27, fig. 15. Turner, 1938:89–90, pl. 20, figs. 1–2. Effinger, 1938:378. Weaver, 1943:351–352, pl. 71, figs. 16, 20; pl. 103, fig. 3; 1953:29. Stewart, 1946:pl. 11, fig. 5. Kleinpell and Weaver, 1963:186, pl. 24, fig. 7. Hickman, 1969:79, 82, pl. 11, figs. 7–8; 1980:33–34, pl. 2, figs. 18–21. Smith, 1975:469, table 2. Givens and Kennedy,

Figures 28–48. Little River area upper Crescent Formation, gastropods and bivalves. CSUN loc. 1553 unless otherwise noted. All specimens coated with ammonium chloride. 28–43. Gastropods. 28. *Diodora* sp., internal mold, dorsal view, $\times 5.9$, LACMIP hypotype 12221. 29, 30. *Homalopoma* sp. cf. *H. umpquaensis domenginensis* Vokes, 1939, $\times 4.4$, LACMIP hypotype 12222, CSUN loc. 1555. 29. Apertural view. 30. Abapertural view. 31, 32. *Homalopoma* sp. aff. *H. watti* (Dickerson, 1916), $\times 4.9$, LACMIP hypotype 12223. 31. Apertural view. 32. Oblique apertural view. 33. *Turritella andersoni* Dickerson, 1916, partial specimen, apertural view, $\times 8.5$, LACMIP hypotype 12224. 34, 35. *Tenagodus bajaensis* Squires, 1990, internal molds. 34. Apertural view, $\times 2$, LACMIP hypotype 12225. 35. Oblique view of longitudinal slit on body whorl, $\times 4$, LACMIP hypotype 12226. 36. *Calyptraea diegoana* (Conrad, 1855), lateral view, $\times 4.2$, LACMIP hypotype 12227, CSUN loc. 1555. 37, 38. *Eratotrivia crescentensis* (Weaver and Palmer, 1922), $\times 6.9$, LACMIP hypotype 12228. 37. Abapertural view. 38. Abapertural view. 39. *Colwellia* sp., apertural view, $\times 5$, LACMIP hypotype 12229. 40. *Dentimitra cretacea* (Gabb, 1864), apertural view, anterior end missing, $\times 5$, LACMIP hypotype 12230, CSUN loc. 1555. 41. *Lyria andersoni* Waring, 1917, apertural view, $\times 5.7$, LACMIP hypotype 12231. 42. *Surculites mathewsonii* (Gabb, 1864), lateral view, $\times 4$, LACMIP hypotype 12232, CSUN loc. 1560. 43. *Conus* sp., abapertural view, $\times 3.4$, LACMIP hypotype 12233. 44–48. Bivalves. 44. *Acila* (*Truncacila*) *decisa* (Conrad, 1855), left valve, $\times 3.7$, LACMIP hypotype 12234. 45. *Barbatia* sp. aff. *B. (B.) landesi* (Weaver and Palmer, 1922), internal mold, left valve, $\times 2.5$, LACMIP hypotype 12235. 46, 47. *Glycymeris* sp. cf. *G. crescentensis* Weaver and Palmer, 1922. 46. Left? valve, $\times 5$, LACMIP hypotype 12236. 47. Left-valve interior, $\times 2.1$, LACMIP hypotype 12237. 48. *Glycymeris* (*Glycymerita*) *sagittata* (Gabb, 1864), right? valve, $\times 1.8$, LACMIP hypotype 12238.



1979:table 2. Deméré, Sundberg, and Schram, 1979:pl. 2, fig. 7. Squires, 1984:21, fig. 6q; 1987:32, fig. 4; 1988a:11, fig. 19; 1991:pl. 1, fig. 20.

PRIMARY TYPE MATERIAL. USNM holotype 1856, Tejon? horizon, San Diego, California.
ILLUSTRATED SPECIMEN. LACMIP hypotype 12227.

MOLLUSCAN STAGE RANGE. "Martinez" (upper Paleocene) through lower Oligocene.

GEOGRAPHIC RANGE. San Diego, California, to Little River area, Washington.

LOCAL OCCURRENCE. CSUN locs. 1553, 1555.

REMARKS. Specimens are uncommon at both localities. This is the first confirmed report of this species in the Crescent Formation. Although Arnold and Hannibal (1913:572) listed this species in a faunal list of macrofossils from the Crescent Formation in the Crescent Bay area, Washington, their specimens were not available for study.

Family Triviidae Troschel, 1863

Genus *Eratotrivia* Sacco, 1894

Eratotrivia crescentensis
(Weaver and Palmer, 1922)

Figures 37, 38

Eratopsis crescentensis Weaver and Palmer, 1922:36-37, pl. 11, figs. 10, 22. Weaver, 1943:393, pl. 76, fig. 21.

Eratotrivia crescentensis (Weaver and Palmer). Schilder and Schilder, 1971:12.

PRIMARY TYPE MATERIAL. UW holotype 201, Crescent Formation at Crescent Bay, Clallam County, Washington, UW loc. 358.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12228.

MOLLUSCAN STAGE RANGE. "Capay."

GEOGRAPHIC RANGE. Little River area and Crescent Bay, Washington.

LOCAL OCCURRENCE. CSUN loc. 1553.

REMARKS. Specimens are uncommon at locality 1553. Preservation is good, and the surface ornamentation is well delineated. Previously, this species was known only from the Crescent Bay area, Washington (Weaver, 1943).

Family Nassariidae Iredale, 1916

Genus *Colwellia*
Nuttall and Cooper, 1973

Colwellia sp.

Figure 39

ILLUSTRATED SPECIMEN. LACMIP hypotype 12229.

LOCAL OCCURRENCE. CSUN loc. 1553.

REMARKS. Only a single, poorly preserved specimen was found. Preservation is too poor to allow identification to species. The specimen resembles *Colwellia antiquata* (Gabb, 1864:97, pl.

18, fig. 50) known from lower to upper middle Eocene strata in southern California and southwestern Oregon (Allmon, 1990). The Little River area specimen of *Colwellia* is the first record of this genus from the Crescent Formation.

Family Mitridae Swainson, 1831

Genus *Dentimitra* Koenen, 1890

Dentimitra cretacea (Gabb, 1864)

Figure 40

Mitra cretacea Gabb, 1864:103, pl. 28, fig. 215.

Stewart, 1927:406, pl. 27, figs. 9-10.

Mitra cretacea Gabb var. Turner, 1938:74, pl. 15, fig. 9. Weaver, 1943:497, pl. 95, figs. 5, 6.

Uromitra (?) *cretacea* (Gabb). Vokes, 1939:134-135, pl. 18, fig. 19.

Proximitra? *cretacea* (Gabb). Givens, 1974:87. Squires, 1977:table 1; 1984:34, fig. 8p.

Dentimitra cretacea (Gabb). Cernohorsky, 1976:510.

PRIMARY TYPE MATERIAL. ANSP holotype 4302, Tejon Formation s.l., Martinez, California.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12230.

MOLLUSCAN STAGE RANGE. "Capay" through "Domengine."

GEOGRAPHIC RANGE. Simi Valley, southern California, to Little River area, Washington.

LOCAL OCCURRENCE. CSUN loc. 1555.

REMARKS. Only a single specimen was found. It is well preserved except for missing the anterior end of the shell. This specimen is unworn and shows the sculpture better than any other illustrated specimen of this species. This is the first report of this species from the Crescent Formation and from Washington. Previously, the northern limit of this species was southwestern Oregon (Turner, 1938).

Family Volutidae Rafinesque, 1815

Genus *Lyria* Gray, 1847b

Lyria andersoni Waring, 1917

Figure 41

Cancellaria irelaniana Cooper. Arnold, 1910:52, pl. 4, fig. 22. Not *Cancellaria irelaniana* Cooper, 1894.

Lyria andersoni Waring, 1917:97, pl. 15, fig. 12. Clark, 1929:pl. 9, figs. 7-8. Clark and Vokes, 1936:876, pl. 1, fig. 17. Turner, 1938:73, pl. 18, fig. 5. Vokes, 1939:136, pl. 18, figs. 22, 24. Hanna and Hertlein, 1941:170, fig. 62-21. Squires, 1984:35, pl. 9d; 1987:47, fig. 69; 1988a:16, fig. 36; 1988c:pl. 1, fig. 16; 1991:pl. 2, fig. 8. Squires and Demetron, 1992:33, fig. 90.

PRIMARY TYPE MATERIAL. SU holotype 195, SU paratype 196, Lajas Formation, Simi Valley, Ventura County, California, SU loc. 2696.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12231.

MOLLUSCAN STAGE RANGE. "Capay" through "Domengine."

GEOGRAPHIC RANGE. Eastern Laguna San Ignacio area, Baja California Sur, Mexico, to Little River area, Washington.

LOCAL OCCURRENCE. CSUN loc. 1553.

REMARKS. Specimens are rare. This is the first report of this species from the Crescent Formation and from Washington. Previously, the northern limit of this species was southwestern Oregon (Turner, 1938).

Family Turridae Swainson, 1840

Genus *Surculites* Conrad, 1865

Genus *Surculites mathewsonii*
(Gabb, 1864)

Figure 42

Fusus mathewsonii Gabb, 1864:83, pl. 18, fig. 33.

Dickerson, 1914:pl. 16, fig. 2.

Bela clathra Gabb, 1869:152, pl. 26, fig. 31.

?*Pleurotoma decipiens* Cooper, 1894:40, pl. 2, fig. 32.

Potamides? davisiana Cooper, 1894:44, pl. 1, fig. 13.

Surcula davisiana (Cooper). Dickerson, 1913:279, pl. 12, figs. 6a–b.

Surcula(?) sp. Waring, 1917:pl. 15, fig. 16.

Surcula decipiens (Cooper). Hanna, 1927:324, pl. 54, figs. 6, 8.

Surculites mathewsonii (Gabb). Stewart, 1927:420–421, pl. 26, figs. 12–14. Clark, 1929:pl. 9, figs. 3–4. Turner, 1938:69–70, pl. 17, figs. 6, 10. Vokes, 1939:123, pl. 17, figs. 8, 19. Weaver, 1943:526, pl. 97, figs. 24, 29; pl. 98, figs. 1, 5; 1953:29. Givens, 1974:90, pl. 11, figs. 5, 7. Zinsmeister, 1974:164, pl. 17, fig. 6; 1983:table 1. Squires, 1977:table 1; 1984:37, fig. 9j; 1987:48, fig. 73; 1991:pl. 2, fig. 11. Givens and Kennedy, 1979:87, tables 1, 3.

PRIMARY TYPE MATERIAL. ANSP lectotype 4180, designated by Stewart (1927), Tejon Formation s.l., near Martinez, northern California.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12232.

MOLLUSCAN STAGE RANGE. “Martinez” (upper Paleocene) through “Transition.”

GEOGRAPHIC RANGE. San Diego, California, to Little River area, Washington.

LOCAL OCCURRENCE. CSUN loc. 1560.

REMARKS. Specimens are rare. This is the first report of this species from the Crescent Formation and from Washington. Previously, the northern limit of this species was southwestern Oregon (Turner, 1938).

Family Conidae Rafinesque, 1815

Genus *Conus* Linné, 1758

Conus sp.

Figure 43

ILLUSTRATED SPECIMEN. LACMIP hypotype 12233.

LOCAL OCCURRENCE. CSUN locs. 1553, 1555.

REMARKS. Specimens are uncommon and too poorly preserved to allow identification as to species. The specimens are prominently noded. This is the first report of this genus from the Crescent Formation.

Class Bivalvia Linné, 1758

Order Nuculoida Dall, 1889

Family Nuculidae Gray, 1824

Genus *Acila*

H. and A. Adams, 1858

Subgenus *Truncacila* Schenck,
in Grant and Gale, 1931

Acila (Truncacila) decisa
(Conrad, 1855)

Figure 44

Nucula decisa Conrad, 1855:11–12; 1857:pl. 3, fig. 19.

Acila gabbiana Dickerson, 1916:481, pl. 36, fig. 1. Anderson and Hanna, 1925:176, pl. 9, fig. 12.

Nucula (Acila) stillwaterensis Weaver and Palmer, 1922:6, pl. 8, fig. 8.

Acila lajollaensis Hanna, 1927:270, pl. 25, figs. 1, 3, 5, 7–8, 12, 15.

Acila (Truncacila) decisa (Conrad). Schenck, 1936:53–56, pl. 3, figs. 1–9, 11–15; pl. 4, figs. 1–2; text fig. 7 (22, 23, 25). Turner, 1938:41–42, pl. 5, figs. 2–3. Vokes, 1939:41, pl. 1, figs. 7–8. Weaver, 1943:22–23, pl. 6, figs. 1, 4, 8; pl. 7, figs. 8–9. Moore, 1968:30, pl. 13a; 1983:10, pl. 1, fig. 14. Givens, 1974:38, pl. 1, fig. 1. Zinsmeister, 1974:67–68, pl. 6, fig. 3; 1983:table 1. Squires, 1977:table 1; 1984:41, fig. 10a; 1987:54, fig. 86; 1988a:17, fig. 44; 1991:pl. 2, fig. 15. Throckmorton, 1988:pl. 1, fig. 19.

PRIMARY TYPE MATERIAL. UCMP neotype 31132, designated by Schenck (1936), Ardath Shale, UCMP loc. 5062.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12234.

MOLLUSCAN STAGE RANGE. “Martinez” through upper Eocene (*Turritella schencki delaguerrae* Zone of Kleinpell and Weaver, 1963).

GEOGRAPHIC DISTRIBUTION. San Diego, California, through Kamchatka, Russia.

LOCAL OCCURRENCE. CSUN locs. 1553, 1554.

REMARKS. Specimens are rare at both localities and consist of broken single valves. This is the first report of this species from the Crescent Formation. Previously, it had been reported from the Cowlitz Formation in Washington (Weaver, 1943).

Order Arcoida Stoliczka, 1871

Family Arcidae Lamarck, 1809

Genus *Barbatia* Gray, 1842

Subgenus *Barbatia* s.s.

Barbatia sp. aff. *B. (B.) landesi*
(Weaver and Palmer, 1922)

Figure 45

Arca (Barbatia) landesi Weaver and Palmer, 1922:
9–10, pl. 8, fig. 4.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12235.

LOCAL OCCURRENCE. CSUN locs. 1553, 1553a, 1555, 1557, 1558.

REMARKS. Specimens are common at locality 1553 and rare at the other localities. Specimens are fragments of single valves resembling *Barbatia (B.) landesi* (Weaver and Palmer, 1922) from the upper middle Eocene Cowlitz Formation, southwestern Washington. The Crescent Formation specimens, like *B. (B.) landesi*, have ribs that are not coarsely beaded and that do not dichotomize. The Crescent Formation specimens differ from *B. (B.) landesi* in the following features: dorsal margin slopes down just anterior to the umbones (rather than projecting a moderate distance) and no tendency for secondary ribs in the interspaces. This is the first report of genus *Barbatia* from the Crescent Formation.

Family Glycymerididae
Newton, 1922

Genus *Glycymeris* da Costa, 1778

Glycymeris sp. cf. *G. crescentensis*
Weaver and Palmer, 1922
Figures 46, 47

Glycymeris crescentensis Weaver and Palmer, 1922:
11, pl. 8, figs. 10, 12.

ILLUSTRATED SPECIMENS. LACMIP hypotype 12236–12237.

LOCAL OCCURRENCE. CSUN locs. 1553, 1557.

REMARKS. Specimens are abundant at locality 1557 and common at locality 1553. Preservation is too poor to allow positive species identification. The specimens are assigned tentatively to *G. crescentensis* Weaver and Palmer, 1922, known from lower Eocene strata in southwestern Oregon and from the Crescent Formation at Crescent Bay, Washington (Turner, 1938; Weaver, 1943).

Subgenus *Glycymerita*
Finlay and Marwick, 1937

Glycymeris (Glycymerita)
sagittata (Gabb, 1864)
Figure 48

Axinaea (Limopsis?) sagittata Gabb, 1864:197–198,
pl. 31, figs. 267–267a.

Glycymeris hannibali Dickerson, 1916:483, pl. 36,
figs. 8a–b.

Glycymeris sagittatus (Gabb). Dickerson, 1916:pl.
36, figs. 5a–b.

Glycymeris sagittata (Gabb). Anderson and Hanna,
1925:181–182, pl. 1, fig. 6. Stewart, 1930:71–73,
pl. 12, fig. 10; 1946:pl. 12, fig. 3. Turner, 1938:
43–44, pl. 6, figs. 1–3 [as “*Glycymeris*”]. Vokes,
1939:45–46, pl. 1, figs. 18–20. Weaver, 1943:54–
55, pl. 9, figs. 17–18; pl. 11, fig. 15. Kleinpell and
Weaver, 1963:196–197, pl. 28, fig. 10; pl. 29, figs.
1–2. Deméré, Sundberg, and Schram, 1979:pl. 1,
figs. 1–2.

Glycymeris (Glycymerita) sagittata (Gabb). Givens,
1974:42–43. Squires, 1977:table 1; 1984:42, fig.
10d; 1987:56, fig. 91; 1988a:17–18, fig. 46. Dev-
yatilova and Volobueva, 1981:37, pl. 11, fig. 4.
Moore, 1983:54–55, pl. 12, fig. 17. Marinovich,
1988:269, pl. 1, fig. 3. Squires and Demetron,
1992:36–37, figs. 100, 101.

PRIMARY TYPE MATERIAL. ANSP lectotype
4422, designated by Stewart (1930:72). Tejon For-
mation near Ft. Tejon (N½ of section 29, T 10 N,
R 19 W, Kern County, California).

ILLUSTRATED SPECIMEN. LACMIP hypo-
type 12238.

MOLLUSCAN STAGE RANGE. “Capay”
through “Tejon,” Oligocene?

GEOGRAPHIC RANGE. Eastern Laguna San Ig-
nacio area, Baja California Sur, Mexico, through
far eastern Russia.

LOCAL OCCURRENCE. CSUN locs. 1553,
1554.

REMARKS. Specimens are rare. This is the first
report of this species from the Crescent Formation.

Subgenus *Tucetona* Iredale, 1931

Glycymeris (Tucetona)
fresnoensis Dickerson, 1916
Figure 49

Glycymeris fresnoensis Dickerson, 1916:483, pl. 36,
fig. 7. Turner, 1938:44, pl. 5, fig. 9.

Glycymeris fresnoensis Dickerson. Vokes, 1939:48,
pl. 1, fig. 17. Weaver, 1943:pl. 11, fig. 11.

Glycymeris (Tucetona) fresnoensis Dickerson.
Moore, 1983:55, pl. 12, figs. 2, 3.

PRIMARY TYPE MATERIAL. UCMP holo-
type 11795, Cerros Shale Member of the Lodo
Formation, Fresno County, California, UCMP loc.
1817.

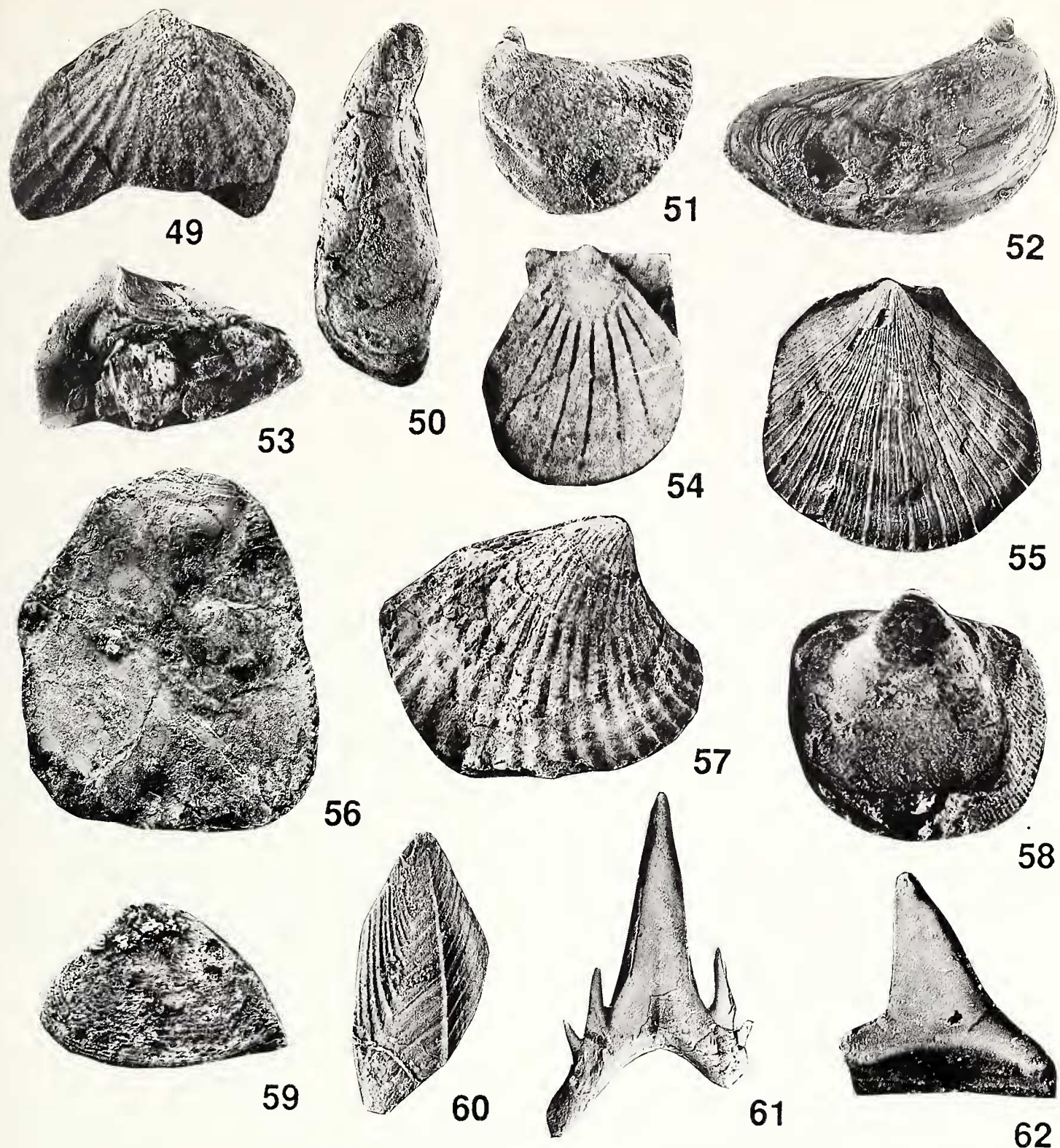
ILLUSTRATED SPECIMEN. LACMIP hypo-
type 12239.

MOLLUSCAN STAGE RANGE. “Capay.”

GEOGRAPHIC RANGE. Central California
through Crescent Bay, Washington.

LOCAL OCCURRENCE. CSUN locs. 1553,
1557.

REMARKS. Specimens are rare. This small spe-
cies is characterized by 16 sharp radial ribs. Squires



Figures 49–62. Little River area upper Crescent Formation, bivalves, “gooseneck” barnacle, and shark teeth. CSUN loc. 1553 unless otherwise noted. All specimens coated with ammonium chloride. **49–59.** Bivalves. **49.** *Glycymeris* (*Tucetona*) *fresnoensis* Dickerson, 1916, left? valve, $\times 5.5$, LACMIP hypotype 12239. **50.** *Brachidontes* (*Brachidontes*) *cowlitzensis* (Weaver and Palmer, 1922), right valve, dorsal view, $\times 1.9$, LACMIP hypotype 12240. **51–53.** *Nayadina* (*Exputens*) *batequensis* Squires, 1990. **51.** Right valve, $\times 3$, LACMIP hypotype 12241. **52.** Left valve, $\times 2.1$, hypotype LACMIP 12242. **53.** Left-valve interior, $\times 2.4$, LACMIP hypotype 12243. **54.** *Parvamussium* sp., left? valve, $\times 1.5$, LACMIP hypotype 12244, CSUN loc. 1555. **55.** *Spondylus carlosensis* Anderson, 1905, left valve, $\times 2.7$, LACMIP hypotype 12245, CSUN loc. 1555. **56.** “*Ostrea*” sp., left-valve interior, $\times 1.7$, LACMIP hypotype 12246. **57.** *Venericardia* sp., internal mold, right valve, $\times 1.6$, LACMIP hypotype 12247. **58.** *Nemocardium linteum* (Conrad, 1855), internal mold, left? valve, $\times 4.4$, LACMIP hypotype 12248. **59.** *Corbula* (*Caryocorbula*) *dickersoni* Weaver and Palmer, 1922, left valve, $\times 4$, LACMIP hypotype 12249. **60.** *Aporolepas* sp., tergum, $\times 3.6$, LACMIP hypotype 12250, CSUN loc. 1554. **61.** *Paleohypotodus* sp., anterior tooth, labial view, $\times 2.7$, LACMVP 134133, CSUN loc. 1553 = LACMVP loc. 6117. **62.** *Isurus?* sp., upper lateral? tooth, lingual view, $\times 5.4$, LACMVP 134434, CSUN loc. 1560a = LACMVP loc. 6123.

(1988b) allocated UCMF locality 1817 to the “Cay Stage.” Although Weaver (1943) listed this species from the Domengine Formation of central California, Vokes (1939) clearly stated that it is not found in that formation.

Order Mytiloida Férussac, 1822
 Family Mytilidae Rafinesque, 1815
 Genus *Brachidontes* Swainson, 1840

Subgenus *Brachidontes* s.s.

Brachidontes (*Brachidontes*)
cowlitzensis Weaver and Palmer, 1922

Figure 50

Modiola ornata Gabb, 1864:184–185, pl. 24, fig. 166. Not *Mytilus ornatus* d'Orbigny, 1843:283, pl. 342, figs. 10–12.

Modiolus ornatus Gabb. Arnold, 1907:pl. 38, fig. 4.

Modiolus (*Brachydontes*) *cowlitzensis* Weaver and Palmer, 1922:16–17, pl. 9, fig. 19 [*nom. nov.*].

Brachydontes ornatus (Gabb). Anderson and Hanna, 1925:188, pl. 3, fig. 4.

Modiolus (*Brachydontes*) *ornatus* Gabb. Clark and Woodford, 1927:89, pl. 14, fig. 10. Clark, 1929: pl. 3, fig. 6.

Brachidontes cowlitzensis (Weaver and Palmer). Turner, 1938:45–46, pl. 6, figs. 7–8. Kleinpell and Weaver, 1963:197, pl. 29, fig. 3. Wolfe, 1977:3. Givens and Kennedy, 1979:table 2.

VolSELLA (*Brachidontes*) *cowlitzensis* (Weaver and Palmer). Weaver, 1943:113–114, pl. 26, fig. 4.

Brachidontes (*Brachidontes*) *cowlitzensis* (Weaver and Palmer). Givens, 1974:43. Squires, 1977:table 1; 1984:42, fig. 10e; 1987:56, fig. 92; 1988a:18, fig. 47. Moore, 1983:66–67, pl. 17, fig. 1. Throckmorton, 1988:pl. 1, fig. 7. Marinovich, 1988: 269–270, pl. 1, fig. 4.

PRIMARY TYPE MATERIAL. ANSP lectotype 4450 of *Modiola ornata* Gabb, designated by Stewart (1930), Dominguez Formation, Martinez, California. CAS holotype 7406 of *Modiolus* (*Brachydontes*) *cowlitzensis* Weaver and Palmer, Cowlitz Formation, Lewis County, Washington, UW loc. 329.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12240.

MOLLUSCAN STAGE RANGE. “Meganos” through lower Oligocene (*Turritella variata lorenzana* Zone of Kleinpell and Weaver, 1963).

GEOGRAPHIC RANGE. San Diego, California, through Gulf of Alaska.

LOCAL OCCURRENCE. CSUN locs. 1553, 1557.

REMARKS. Specimens are rare. This is the first confirmed report of this species from the Crescent Formation. Arnold and Hannibal (1913) listed this species in a faunal list of macrofossils from the Crescent Formation in the Crescent Bay area, Washington.

Order Pteroida Newell, 1965

Family Malleidae Lamarck, 1819

Genus *Nayadina*
Munier-Chalmas, 1864

Subgenus *Exputens* Clark, 1934

Nayadina (*Exputens*) *batequensis*
Squires, 1990a
Figures 51, 52, 53

Nayadina (*Exputens*) *batequensis* Squires, 1990a: 308–309, figs. 3–25; 1992:133–134, figs. 1–6. Squires and Demetrian, 1992:37, fig. 103.

PRIMARY TYPE MATERIAL. IGM holotype 5108, IGM paratypes 5109–5110, Bateque Formation, eastern Laguna San Ignacio area, Baja California Sur, Mexico, CSUN loc. 1220b.

ILLUSTRATED SPECIMENS. LACMIP hypotype 12241–12242.

MOLLUSCAN STAGE RANGE. “Capay.”

GEOGRAPHIC RANGE. Northwestern Jamaica; Baja California Sur, Mexico; and Little River area, Washington.

LOCAL OCCURRENCE. CSUN locs. 1553, 1554, 1555, 1557.

REMARKS. Specimens are abundant at localities 1553 and 1554 but are rare at the other two localities. This is the first report of this species from the Crescent Formation and from Washington. Previously, it had only been found in the lower to middle Eocene Chapelon Formation, northwestern Jamaica and in the middle lower Eocene (“Capay Stage”) parts of the Tepetate and Bateque Formations, Baja California Sur, Mexico (Squires, 1990a, 1992; Squires and Demetrian, 1992).

Order Pteroida Newell, 1965

Family Propeamussiidae Abbott, 1954

Genus *Parvamussium* Sacco, 1897

Parvamussium sp.
Figure 54

ILLUSTRATED SPECIMEN. LACMIP hypotype 12243.

LOCAL OCCURRENCE. CSUN locs. 1553a, 1554, 1555.

REMARKS. Specimens are uncommon at locality 1553a and rare at the other localities. The specimens are small (2–3 mm height) and show only the right-valve interior. There are 10 ribs that extend almost to the ventral margin. *Parvamussium* is characterized by internal ribs that extend to, or almost to, the ventral margin (Moore, 1984). There are three known Paleogene species of *Parvamussium* from the Pacific coast of North America and they all have 10–12 interior ribs (Moore, 1984). Due to the absence of any data on the exterior sculpture, identification to species is not possible for the Little River area specimens. *Parvamussium* sp. was previously reported from the Crescent Formation at Pulali Point (Squires et al., 1992).

Family Spondylidae Gray, 1826

Genus *Spondylus* Linné, 1758

Spondylus carlosensis

Anderson, 1905

Figure 55

Spondylus carlosensis Anderson, 1905:194, pl. 13, fig. 1. Arnold, 1910:pl. 2, figs. 6–7. Dickerson, 1915:pl. 1, fig. 7. Anderson and Hanna, 1925:189–190, text fig. 10. Vokes, 1939:57, pl. 3, figs. 10, 13. Kleinpell and Weaver, 1963:199, pl. 31, fig. 6. Squires, 1984:43, fig. 10j.

PRIMARY TYPE MATERIAL. CAS holotype 56, Domengine Formation, west and north of Coalinga, NW¼ of section 35, T 20 S, R 14 E, Fresno County, California.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12245.

MOLLUSCAN STAGE RANGE. “Capay” through “Domengine.”

GEOGRAPHIC RANGE. Simi Valley, southern California, through Little River area, Washington.

LOCAL OCCURRENCE. CSUN locs. 1553, 1553a, 1554, 1555, 1556, 1557.

REMARKS. Specimens are abundant at locality 1553, uncommon at 1554 and 1556, and rare elsewhere. All specimens are single valves and many of these are preserved as molds.

The Little River area specimens of *Spondylus carlosensis* Anderson, 1905, are the earliest record of this species from the Pacific coast of North America and the first record from the Crescent Formation and from Washington. Previously, it had been reported only from the “Domengine Stage” (Squires, 1984) and had been found as far north as northwestern Oregon (Baldwin, 1964).

Family Ostreidae Rafinesque, 1815

Genus *Ostrea* Linné, 1758

Ostrea sp.

Figure 56

ILLUSTRATED SPECIMEN. LACMIP hypotype 12246.

LOCAL OCCURRENCE. CSUN locs. 1553, 1554, 1555, 1556.

REMARKS. Specimens are abundant at locality 1553 and rare at the other localities. Most specimens are fragments. The illustrated specimen is a complete single valve that shows only the interior. Due to the absence of any data on the exterior sculpture, species identification is not possible. The specimen strongly resembles *Ostrea* sp. from the Crescent Formation at Pulali Point (Squires et al., 1992:pl. 1, figs. 30–31).

Order Veneroida

H. and A. Adams, 1856

Family Carditidae Fleming, 1828

Genus *Venericardia* Lamarck, 1801

Venericardia sp.

Figure 57

ILLUSTRATED SPECIMEN. LACMIP hypotype 12247.

LOCAL OCCURRENCE. CSUN locs. 1553, 1554.

REMARKS. Specimens are common at locality 1553 and rare at 1554. Specimens are small fragments of single valves. Preservation is too poor to allow positive identification to species. The specimens, which have approximately 20 radial ribs, are quadrate and resemble the illustrated specimen (Squires et al., 1992:pl. 1, fig. 32) of *Venericardia hornii* s.s. (Gabb, 1864) from the Crescent Formation at Pulali Point, Washington.

Family Cardiidae Lamarck, 1809

Nemocardium linteum

(Conrad, 1855)

Figure 58

Cardium linteum Conrad, 1855:3, 9; 1857:pl. 2, fig. 1. Anderson and Hanna, 1925:166–167, pl. 3, fig. 3.

Cardium cooperii Gabb, 1864:172, pl. 24, figs. 154–154a. Arnold, 1907:pl. 38, figs. 2–2a. Waring, 1917:pl. 13, fig. 3. Hanna, 1927:285, pl. 41, figs. 6, 7.

Cardium dalli Dickerson, 1913:289, pl. 14, figs. 4a–c. Not *Cardium dalli* Heilprin, 1887:131, pl. 16a, fig. 70.

Cardium marysvillensis Dickerson, 1916:482 [nom. nov.].

Cardium (*Protocardium*) *marysvillensis* Dickerson. Clark and Woodford, 1927:94, pl. 15, fig. 12.

Nemocardium linteum (Conrad). Stewart, 1930:275–277, pl. 8, fig. 6. Turner, 1938:52, pl. 10, fig. 10. Vokes, 1939:76–77, pl. 11, figs. 6, 9. Weaver, 1943:159–160, pl. 38, fig. 3; 1953:28. Stewart, 1946:pl. 11, fig. 19. Moore, 1968:30, pl. 13d. Zinsmeister, 1974:97–98, pl. 9, figs. 7–9; 1983:pl. 2, fig. 7. Givens and Kennedy, 1979:table 4. Squires, 1984:49–50, fig. 12c; 1987:65, 67, fig. 113; 1988a:19, fig. 51. Squires et al., 1992:pl. 1, fig. 33. Squires and Demetron, 1992:42, fig. 121.

Cardium (*Nemocardium*) *lin-teum* Conrad. Kleinpell and Weaver, 1963:202, pl. 34, fig. 4.

Nemocardium (*Nemocardium*) *lin-teum* (Conrad). Givens, 1974:49. Squires, 1977:table 1.

PRIMARY TYPE MATERIAL. USNM holotype 1834, Domengine Formation near Martinez, California.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12248.

MOLLUSCAN STAGE RANGE. “Martinez” through “Tejon.”

GEOGRAPHIC RANGE. Eastern Laguna San Ignacio area, Baja California Sur, Mexico, through Pulali Point, Washington.

LOCAL OCCURRENCE. CSUN locs. 1553, 1553a, 1554, 1555.

REMARKS. Specimens are uncommon at locality 1553 and rare at the other localities.

Order Myoida Stoliczka, 1870
Family Corbulidae Lamarck, 1818
Genus *Corbula* Bruguière, 1797

Subgenus *Caryocorbula*
Gardner, 1926

Corbula (*Caryocorbula*)
dickersoni

Weaver and Palmer, 1922
Figure 59

Corbula dickersoni Weaver and Palmer, 1922:24–25, pl. 9, figs. 9–10. Clark, 1938:700, pl. 1, fig. 17. Weaver, 1943:257–258, pl. 61, figs. 13, 16–17, 20. Deméré, Sundberg, and Schram, 1979:pl. 2, fig. 11.

Corbula (*Caryocorbula*) *dickersoni* Weaver and Palmer. Vokes, 1939:98, pl. 16, figs. 1, 5, 9. Givens, 1974:57, pl. 4, fig. 7. Squires, 1984:53, fig. 12m; 1987:70–71, fig. 124.

PRIMARY TYPE MATERIAL. CAS holotype 7452, CAS paratypes 7452A–B, Cowlitz Formation, Lewis County, Washington, UW loc 329.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12249.

MOLLUSCAN STAGE RANGE. “Capay” through “Tejon.”

GEOGRAPHIC RANGE. San Diego, California, through Little River area, Washington.

LOCAL OCCURRENCE. CSUN loc. 1553.

REMARKS. Specimens are rare. This is the first confirmed report of this species from the Crescent Formation. Squires et al. (1992) tentatively reported it from the Crescent Formation at Pulali Point, Washington.

Phylum Arthropoda
Siebold and Stannius, 1848

Class Cirripedia
Burmeister, 1834

Order Thoracica Darwin, 1854

Family Scalpellidae
Pilsbry, 1916

Genus *Aporolepas*
Withers, 1953

Aporolepas sp.
Figure 60

ILLUSTRATED SPECIMEN. LACMIP hypotype 12250.

LOCAL OCCURRENCE. CSUN locs. 1553, 1554.

REMARKS. A single capitular plate was found at each locality. The Little River area specimens of this genus constitute the first published record of *Aporolepas* from the Pacific coast of North America. One other locality is in the middle Eocene

Torrey Sandstone in San Diego County, southern California (V.A. Zullo, pers. comm., 1993).

Phylum Chordata Balfour, 1880

Class Chondrichthyes
Huxley, 1880

Order Lamniformes Berg, 1958

Family Odontaspidae
Müller and Henle, 1837

Genus *Palaeohypotodus*
Glückman, 1964

Palaeohypotodus sp.
Figure 61

ILLUSTRATED SPECIMEN. LACMVP 134133.

LOCAL OCCURRENCE. CSUN loc. 1553.

REMARKS. A single specimen was found. It closely resembles *P. rutoti* (Winkler, 1874) from the Paleocene of western Europe, Greenland, Maryland, and North and South Dakota, as well as from the lower Eocene (Ypresian Stage) of western Europe (Cappetta, 1987; Ward and Wiest, 1990; Cvancara and Hoganson, 1993). Cappetta (1987:88, figs. 27A–C, 79E–J) and Cvancara and Hoganson (1993:figs. 3MM–3NN) illustrated *P. rutoti*.

The Little River area specimen is the first record of *Palaeohypotodus* from the Pacific coast of North America.

Family Lamnidae
Müller and Henle, 1838

Genus *Isurus* Rafinesque, 1810

Isurus? sp.
Figure 62

ILLUSTRATED SPECIMEN. LACMVP 134434.

LOCAL OCCURRENCE. CSUN loc. 1560a.

REMARKS. A single specimen was found. It is not diagnostic enough to be positively identified as *Isurus*. Previously, *Isurus* has not been reported from the Crescent Formation.

LOCALITIES

CSUN MACROFOSSIL LOCALITIES

1220b. Along a prominent ridge, north side of a minor canyon on the west side of Mesa La Salina, 84–130 m above the bottom of the exposures of the Bateque Formation in this area, approximately 1.25 km southeast of the intersection of 113°00'W and 26°45'N, Mexican government topographic quadrangle map (scale 1:50,000) of San José de Gracia (number G12A64), Baja California Sur, Mexico, 1982.

1291a. South side of a minor canyon near the southern end of Mesa La Salina at 120 m elevation, at 112°56'13"W and 26°40'N, Mexican government topographic quadrangle map (scale 1:50,000) of San José de Gracia (number G12A64), Baja California Sur, Mexico, 1982.

1553. At elevation of 870 ft., pebbly sandstone with

mud matrix, on east side of Little River and logging road, just south of bridge over river, 60 m (200 ft.) south and 570 m (1,900 ft.) west of northeast corner of section 14, T 21 N, R 7 W, USGS topographic quadrangle, Grisdale, Washington, 7.5 minute, provisional edition 1990, 1:24,000.

1553a. Argillaceous siltstone 2 m stratigraphically above CSUN loc. 1553.

1554. At elevation of 760 ft., steeply dipping silty very fine-grained sandstone, on both sides of small stream on north side of road, on line between sections 10 and 15 (and nearly in center of south border of section 10), 720 m (2,400 ft.) west of southeast corner of section 10, T 21 N, R 7 W, USGS topographic quadrangle, Grisdale, Washington, 7.5 minute, provisional edition 1990, 1:24,000.

1555. At elevation of 1,100 ft., pebbly sandstone in roadcut on west side of abandoned logging road, 1,110 m (3,700 ft.) and 510 m (1,700 ft.) west of northeast corner of section 12, T 21 N, R 7 W, USGS topographic quadrangle, Grisdale, Washington, 7.5 minute, provisional edition 1990, 1:24,000.

1556. At elevation of 1,640 ft., pebbly sandstone near ridge top, on west side of logging road, 1,050 m (3,500 ft.) south and 810 m (2,700 ft.) west of northeast corner of section 12, T 21 N, R 7 W, USGS topographic quadrangle, Grisdale, Washington, 7.5 minute, provisional edition 1990, 1:24,000.

1557. At elevation of 1,660 ft., pebbly sandstone, 750 m (2,500 ft.) south and 780 m (2,600 ft.) west of northeast corner of section 12, T 21 N, R 7 W, USGS topographic quadrangle, Grisdale, Washington, 7.5 minute, provisional edition 1990, 1:24,000.

1558. At elevation of 1,470 ft., poorly exposed sandstone on east side of an abandoned logging road on crest of low ridge, 1,170 m (3,900 ft.) south and 660 m (2,200 ft.) west of northeast corner of section 12, T 21 N, R 7 W, USGS topographic quadrangle, Grisdale, Washington, 7.5 minute, provisional edition 1990, 1:24,000.

1559. At elevation of 1,940 ft., pebbly sandstone exposed along a logging road on northwest side of ridge, 480 m (1,600 ft.) south and 960 m (3,200 ft.) west of northeast corner of section 12, T 21 N, R 7 W, USGS topographic quadrangle, Grisdale, Washington, 7.5 minute, provisional edition 1990, 1:24,000.

1560. At elevation of 1,960 ft., sandstone on east side of ridge, 510 m (1,700 ft.) south and 810 m (2,700 ft.) west of northeast corner of section 12, T 21 N, R 7 W, USGS topographic quadrangle, Grisdale, Washington, 7.5 minute, provisional edition 1990, 1:24,000.

1560a. At elevation of 1,960 ft., pebbly sandstone along east side of hill, 600 m (2,000 ft.) south and 870 m (2,900 ft.) west of northeast corner of section 12, T 21 N, R 7 W, USGS topographic quadrangle, Grisdale, Washington, 7.5 minute, provisional edition 1990, 1:24,000.

1563. At elevation of 2,230 ft., roadcut exposure, 300 m (984 ft.) north and 50 m (164 ft.) east of southeast corner of section 1, T 17 N, R 4 W, USGS topographic quadrangle, Capitol Peak, Washington, 7.5 minute, provisional edition 1986, 1:24,000.

1564. At elevation of 530 m, roadcut exposure, 800 m (2,624 ft.) north and 50 m (164 ft.) west of southeast corner of section 25, T 18 N, R 4 W, USGS topographic quadrangle, Summit Lake, Washington, 7.5 minute, 1981, 1:24,000.

CAS LOCALITIES

181. Just back of the Gries Ranch house, about 6.5 km (4 mi.) east of Vader, Lewis County, Washington.

SU LOCALITY

2696. Chivo Canyon, 5 km (3 mi.) N20°E of Bench Mark 961 at Santa Susana, USGS topographic quadrangle, Santa Susana, California, 7.5 minute, 1951 (photorevised 1969), 1:24,000.

UCMP LOCALITIES

714. NE¼ of SE¼ of section 21, T 1 S, R 1 E, Black Hills, Mt. Diablo State Park area, USGS topographic quadrangle, Tassarjara, California, 7.5 minute, 1968, 1:24,000.

1817. Opposite the place where Urruttia Canyon enters Salt Creek, 30 m (98 ft.) up fourth small draw from west end of ridge, SE¼ of the NW¼ of section 15, T 18 S, R 14 E, USGS topographic quadrangle, Joaquin Rocks, California, 7.5 minute, 1969, 1:24,000.

5062. In sea cliff south of mouth of Soledad Valley, due west of midpoint between “P” and “u” of “Pueblo,” USGS topographic quadrangle, Del Mar, California, 7.5 minute, 1967, 1:24,000.

A-1313. In Smith Canyon on west side of Capay Valley and west of Tancred, in the south central part of section 28, T 11 N, R 3 W, USGS topographic quadrangle, Guinda, California, 7.5 minute, 1959 (photorevised 1980), 1:24,000.

A-1315. About 3.2 km (2 mi.) north of Putah Creek and about 7.65 km (4.7 mi.) west-northwest of Winters, near center of section 14, T 8 N, R 2 W, USGS topographic quadrangle, Monticello Dam, California, 7.5 minute, 1959, 1:24,000.

USGS LOCALITY

4617. On southwest flank of Reef Ridge, north of McLure Valley, 3.6 km (2.2 mi.) south-southeast of El Cerrito oil well, section 27, T 23 S, R 17 E, USGS topographic quadrangle Cholame, California, 7.5 minute, 1961, 1:24,000.

UW LOCALITIES

329. On north bank of the Cowlitz River at bend 1.5–2.5 km (0.9–1.5 mi.) east of Vader, section 28, T 1 N, R 2 W, USGS topographic quadrangle, Castle Rock, Washington, 15 minute, 1953, 1:62,500.

353. From boulder-sized rocks not in place but in a modern landslide block, 2 km (1.2 mi.) south of Quilcene on west shore of Quilcene Bay just south of latitude 47°47'30"N, NE¼, section 36, T 27 N, R 2 W, USGS topographic quadrangle, Quilcene, Washington, 7.5 minute, 1953, 1:24,000.

358. At Joyce Station in Crescent Bay area, 0.4 km (0.25 mi.) east of Tongue Point, section 22, T 31 N, R 8 W, USGS topographic quadrangle, Joyce, Washington, 7.5 minute, 1978, 1:24,000.

ARMENTROUT'S LOCALITY

LR-1. Equivalent to CSUN loc. 1553 (see above).

ACKNOWLEDGMENTS

Gail H. Goedert assisted with fieldwork and collecting. Edward C. Wilson (Natural History Museum of Los Angeles County) provided geologic literature on corals. James H. McLean and LouElla Saul (Natural History Museum of Los Angeles County) helped with the identification of some of the gastropods. David R. Lindberg (University of

California, Museum of Paleontology) helped with the identification of the patellogastropods. Victor A. Zullo (University of North Carolina, Wilmington) identified the barnacle and shared his knowledge about *Aporolepas*. Ross E. Berglund (Bainbridge Island, Washington) identified the shrimp and crab remains and provided some geologic literature. J.D. Stewart (Natural History Museum of Los Angeles County) helped identify the shark teeth.

James H. McLean and David R. Lindberg shared their knowledge regarding the status of gastropod systematics. Lindsey T. Groves (Natural History Museum of Los Angeles County) and Charlotte A. Oyer (Oviatt Library, California State University, Northridge) expertly helped in finding many of the more obscure taxonomic references.

Hal L. Heitman and M.V. Filewicz (Unocal Corporation, Houston, Texas) processed a microfossil sample for benthic foraminifers and calcareous nannofossils, respectively. William F. Kamin (Simpson Timber Company, Shelton, Washington) issued a special permit allowing fieldwork to be completed during the dry summer of 1992.

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Received 13 April 1993; accepted 18 February 1994.